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THE SHOCK AND VIBRATION DIGEST

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SVIC NOTES

The 54th Shock and Vibration Symposium was held in Pasadena, California, on October 18-20, 1983. It was a well-attended and highly successful meeting. I would like to thank all of the invited speakers, chairmen, co-chairmen, panelists, presenters and attendees of this symposium. Without your excellent technical support and participation, the symposium would not be possible.

Many participants commented to me on how smoothly the meeting went. The credit for this must go to the staff of SVIC, Rudy Volin, Jessica Hileman, Betty McLaughlin and Mary Gobbett. The credit for the successful administration of the meeting must go to Mrs. Hileman since she was responsible for all of the final arrangements and took care of the dozens of small details necessary to run a successful meeting. I would also like to thank Dr. Ben Wada and all the members of the Jet Propulsion Laboratory who provided such excellent support. The Von Karmen Auditorium at JPL was a superb meeting site. JPL also arranged a tour of some of their more important activities, including their space flight control center and environmental testing facilities. A few short technical presentations on new JPL programs and a short review of JPL's past accomplishments were given and well received. The people who went on the tour were very impressed with the quality of the material presented.

The 54th Shock and Vibration Symposium had several notable features. In the Opening Session, Bob Ryan, of NASA Marshall, did a good job of explaining how the job of the shock and vibration engineer is becoming more and more difficult due to the increasing complexity and nonlinearity of today's spacecraft. In fact, the Opening Session emphasized the increasing usage of space in the future. Three excellent and thought-provoking Plenary talks were given by Strether Smith, George Morosow and Bill Baker. Rudy Volin organized an interesting day-long session on the new MIL-STD-810D and we managed to give away over 300 copies of the new standard at the meeting.

Other sessions at the meeting covered Structural Dynamics, Machinery Dynamics and a collection of Vibration problems. I received many favorable comments about Session 1B on Space Vibration. Credit should go to Jerome Pearson of AFWAL who organized the session and invited several of the speakers.

Other noteworthy features of the meeting were the large number of sessions related to blast and shock including the two full days at JPL which were devoted to Navy problems. Don Lund, Stan Herman and Dave Hurt of Naval Sea Systems Command were mostly responsible for organizing the JPL sessions which included inviting many of the speakers.

A big "Well Done" to all. Thanks for helping us make the 54th Shock and Vibration Symposium a successful one.

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TECHNICAL MEETING ATTENDANCE

It appears that attendance at technical sessions held at meetings continue to decline. In fact, it is not uncommon for authors to talk to each other at many sessions. This does not necessarily imply that engineers are not attending meetings, conferences, and symposia. It means that in many conferences the technical sessions are not the focal point.

I believe there are a number of reasons for this trend. Continued republication of the same material in slightly altered form does not motivate people to attend sessions. Publication of irrelevant material -- whether it is a super-technical treatise, technology with no practical application, or solutions to trivial problems -- is next to worthless. Exhibits and social events often become the focal point of a meeting. While these functions are essential and contribute to the effectiveness of a meeting, their importance must remain in prospective. After all, the technical sessions are the stated principal function of the meeting.

Economics plays a big role in attendance at meetings. Often employers are not willing to spend money on "frills" such as technical meetings. In the absence of new development or crisis, management is reluctant to support long term education of an employee. It is unfortunate when an engineer is requested to perform at optimum level on short notice -- the costs involved for mediocre performance may exceed those expended in a long-term educational program.

In order to stop this declining attendance, I believe we are going to have to select more carefully the material that is presented -- even if it is less of it. More is not always better. The technical sessions need to be brought back as the focal point of the meeting. This can be done in part by establishing guidelines for the material to be presented at meetings. Input on the interests of technical people would be helpful to meeting organizers and planners. This can be accomplished by more questionnaires. In addition, the effort to educate employers and employees (engineers) about the value of long-term learning should be intensified.

R.L.E.

A TECHNICAL NOTE ON EVALUATION OF DAMPERS

T.V. Gopalan*

Abstract. ***The significance of the inverse standing wave ratio (ISWR) test and its role in assessing dampers and in obtaining other information needed for their evaluation are discussed in this technical note.***

The inverse standing wave ratio (ISWR) test has been used to assess the effectiveness of overhead line vibration dampers over the expected range of frequency of aeolian vibration of cables. The ISWR test is recommended as a supplement to dynamic characteristics tests on stockbridge dampers in IS:9708. Based on the results of the two tests the adequacy of the damper regarding both dynamic performance and efficiency can be assessed. The dynamic characteristic tests provide quantitative information regarding damping capacity for a given vertical movement of the damper under kinematic excitation; information is obtained concerning the extent of such movements possible in the field. But the ISWR test indirectly provides both the mobility of the point of attachment of the damper when placed on the conductor and the damping capacity.

Need for an Appropriate Method for Evaluation of Dampers

External dampers have been used in transmission lines to protect cables at suspension points at which fatigue failures have been known to occur. But some dampers cause cable failure at their points of attachment, and the section of cable at the suspension point is not damaged. The damper therefore has shifted the failure from the suspension point to the point at which the protective device is located. The damper thus transfers all or most of the dynamic stresses to a point at which static stresses are less severe than those at the suspension point. This transfer of stresses can be attributed to any of various causes:

- comparatively large mass of the damper
- cable bending at the location of the dampers due to asymmetric action of the damper weights or cables
- an unbalanced torsion on the cable at the point of attachment of the damper

A simple mass suspended on a cable can protect the suspension point by damping the portion of the cable between the suspension point and the mass. However, the mass imposes dynamic stresses on the cable. The attachment of a heavy mass increases the stiffness of the point of attachment and results in dynamic stresses there as well as at the suspension point. The inherent asymmetry of multi-resonance dampers can also cause dynamic stresses at the location of the damper even if the mass of the damper is not great; e.g., cable bending is possible when one of the two masses of a stockbridge damper is in resonance, either in the cantilever mode or the bending mode. Torsion of the cable is possible if significant imbalance exists in the masses of a dog-bone damper.

The mass-like behavior of the stockbridge damper and its variations cannot be assessed by dynamic characteristic tests. The ISWR test is useful in assessments but does not seem to be helpful in assessing the bending and twisting action of the cable. There is thus a need to develop a better system of damper evaluation.

Recommended Method for Evaluation

Dynamic characteristic tests on a damper provide quantitative information regarding damping capacity in terms of damping power per unit displacement of damper clamp. No information regarding possible damper displacement in the field is obtained; i.e., the mobility of the point of attachment of damper on the cable while in the field is not obtained. No

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information about added damping and hazard possible at this location can be obtained from these tests. If it is assumed that a damper is immobile due to its mass, it will not contribute any damping even if it possesses good dynamic characteristics. Such a damper will show an ISWR of O.O. Conversely, an ISWR test that shows the desired level of damping indicates that the damper does not cause considerable stiffening of its point of attachment on the cable; hence the damper is performing well. An ISWR test of dampers also serves as an independent means of evaluation.

However, the mass of the damper is a good index when one damper must be chosen from a number of dampers having satisfactory dynamic characteristics and ISWR results. For identical dynamic characteristics and acceptance curves obtained by ISWR tests -- not realized in practice -- the damper weighing the least is the best choice. Unintentional asymmetry in dampers can be assessed by taking physical measurements on the assembled damper and stripping a randomly selected sample; e.g., stripping a stockbridge damper into messenger cable, masses, and clamp.

Evaluation of stockbridge dampers designed with asymmetry with respect to the damper clamp – in other words damper performance is dependent on intentional asymmetry, as in a four-R damper – depends on tolerance levels of results of asymmetry. However, a symmetric stockbridge damper that meets the requirements imposed by an overhead line might be preferable to an asymmetrically designed damper of the same type.

Summary of Recommendations for Evaluation of Dampers

1. If any one test is to be depended on for evaluation of dampers, it is the ISWR test. The damper that is efficient over the desired frequency range is recommended.
2. Dynamic characteristics tests should be complemented by ISWR tests for evaluating dampers. Primary consideration should be given to ISWR test results.
3. Among dampers that are adequate based on ISWR and dynamic characteristics tests, the one that weights least is best.
4. The choice among symmetric dampers should be based on measurements of the assembled damper and of the damper stripped into its components.
5. If an asymmetric and symmetric damper meet the requirements equally, the choice can be the symmetric damper.
6. Conclusions at 4. and 5. above are of minor consideration, however.

Acknowledgement

Thanks are due to the Director of CPRI for granting permission to publish this note. Thanks are also due to Prof. S. Durvasula, Aeronautical Engineering Department, and Prof. G.R. Nagabhushan of High Voltage Engineering, Department of Indian Institute of Science, Bangalore, India, for their guidance in this work. The author also wishes to thank Mr. M. Swaminathan for assistance in preparation of the manuscript.

LITERATURE REVIEW: survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains articles about dynamic behavior of underground structures and stable response of damped linear systems.

Dr. G.D. Manolis of State University of New York, Buffalo, New York has written a review article that provides a brief historical perspective to the general subject of dynamic behavior of underground structures and summarizes the work done in this area during the last few years.

Dr. D.W. Nicholson of Naval Surface Weapons Center, White Oak, Maryland and Dr. D.J. Inman of State University of New York, Buffalo, New York have written a paper that updates and expands a previous review concerned with several aspects of the response of damped mechanical systems. Topics include asymptotic stability, oscillation conditions, forced response bounds, and eigenvalue localization.

DYNAMIC BEHAVIOR OF UNDERGROUND STRUCTURES

G.D. Manolis*

Abstract. This article has two purposes: a) to provide a brief historical perspective to the general subject of dynamic behavior of underground structures and b) to summarize the work done in this area during the last few years. Underground structures can be close to the surface or deeply buried and can be subjected to harmonic, shock, or seismic excitations. Experimental, analytical, and numerical methods of approach are discussed.

There is a great range of use of underground structures. Examples include buried pipelines used to transport liquids and gases; traffic movement through buried tunnels; culverts used for drainage and as underpasses; tunnels cut through mountains; buildings built beneath the surface of the earth to provide storage and to serve as shelters; and vertically buried silos used for placement of delicate machinery and instruments. Reasons for the widespread use of underground structures include conservation of space in crowded urban areas, protection against climatic extremes, and amelioration of some of the effects of dynamic loads imposed by such surface disturbances as earthquakes and air blasts [1-3].

The static behavior of buried structures involves soil arching. Under normal circumstances soil arching develops [4] and transmits to the surrounding soil a large part of the overburden pressure created by the weight of the cover soil. Arching action is substantial even for shallow burial; Krauthammer's [5] recent re-evaluation of experimental data on reinforced concrete box-type structures indicates that soil arching can account for up to 70% of the measured resistance to the static overburden load.

For the majority of underground structures under dynamic loads, soil-structure interaction is negligible. Consequently, the structure conforms to free field soil deformations and small dynamic stresses develop. This type of behavior lends credence to static [6] and quasi-static methods of design [7-9]. These methods assume that the seismic forces a structure experiences can be computed by multiplying the mass of overburden soil by the maximum acceleration that does not cause soil failure. Monitoring of accelerations developed in basements and other embedded structures during small to medium earthquakes [10] confirms this type of behavior. Only if significant inertial and/or stiffness mismatch exists between the structure and the surrounding medium does the possibility of failure due to progressive distortion of the buried structure exist. At present, little information on this case is available.

EXPERIMENTAL WORK

The literature is rich in experimental investigations on the dynamic behavior of underground structures under suddenly applied (shock) loads. Most of this work was done in the 1960s and early 1970s.

Bulson [11] examined the influence of cover depth on the collapse load of horizontally placed thin-walled cylindrical metallic tubes in soil under a surface pressure applied both quasi-statically and dynamically. Failures included local snap buckling of the rim and/or caving of the roof. The collapse pressure in the static case rose rapidly with increasing cover depth until the cover was equal to the diameter of the tube. Thereafter, no significant increase in the collapse pressure occurred with increasing cover. In the dynamic case, complete tube collapse occurred when the peak blast overpressure was in a zone very close to the static pressure that would cause collapse. Results from similar tests [12-15] essentially agree with Bulson's conclusions. Previous investigators [16, 17] had examined the validity of the similitude relations used to extrapolate the dynamic response of real underground structures from experiments on scaled models.

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During the last few years, emphasis in experimental work has shifted from small-scale flexible models, which essentially conform to the free field motions of the soil, to larger scale stiff models [18-22]. The response of 1:30 scaled models of stiff reinforced concrete cylindrical missile shelters subjected to severe dynamic shock loads was examined [19] and compared with the response of similar 1:6 scaled models from a parallel program [18]. In the tests sand was rained over a vertically placed cylinder 4.2 ft in height with a base and a cap. The model was contained in a large rigid facility; explosives produced an air blast that impinged on the soil surface. The stronger of the two models tested exhibited linear elastic response. The other failed because excessive base flexure cracked the base connection of the cylinder. The cylinder itself survived the blast. Good correlation of results between the two programs was obtained. It can therefore be concluded that suddenly applied excitations, generated either by dropping weights or by firing explosive charges, create an extremely fast response. As a result inertial effects do not develop; the buried structure simply experiences a uniform acceleration field.

In sharp contrast to blast loads, oscillators transmit both forces and motions to the buried structure. Various investigators [23-27] have performed forced vibration tests using oscillators or vibration generators. Some results [25] indicate that the exciting force developed in a full scale nuclear reactor building is directly proportional to the frequency of oscillation. In general, oscillators can produce a variable loading force at constant frequency or a force of constant magnitude with varying frequency [26]. Oscillators are used to study the natural frequencies of soil and embedded structure(s).

Little work has been done on buried structures using earthquake simulators. Perhaps the most involved testing to date is a large number of experiments on scaled models of underground stations and tunnels for a subway transport network [28]. A total of 214 tests were completed on two shaking tables. Seventy different structural models were subjected to harmonic, shock, and seismic excitations under conditions of plane strain. The information generated from these tests confirmed qualitative information gained from earthquake observations [10] about the dynamic behavior of horizontally buried structures. In particular, because the majority of these structures have almost the same inertia to stiffness ratio as the material removed, they essentially conform to soil motions; the stresses induced are small compared to the design stresses resulting from the weight of the overburden. The tests also indicated that the dynamic response is more pronounced the closer the structure is to the surface and that the natural frequencies and damping ratios of the soil are virtually unaffected by the presence of the buried model structure. The same behavior patterns were observed in similar experiments [29, 30]. In one case [29] a pile foundation was examined; the deformations of a prefabricated highway tunnel model were measured in the other [30]. Earthquake simulators are useful in that they can accurately reproduce virtually any type of dynamic record.

The behavior of subaqueous buried tunnels during earthquakes was first investigated by Okamoto and Tamura [31], who vibrated three-dimensional models on a shaking table. The test results were necessarily linear elastic because gelatin was used for the soil layers and the tunnel was made of silicon rubber. In addition, earthquake observations were made at the site of the real tunnel, and a mathematical model was formulated for seismic design studies. The results obtained from the experiments, the observations, and the mathematical analyses were consistent and indicated that elastic subaqueous tunnels with no mismatches of inertia and flexibility move in phase with the ground during an earthquake. Furthermore, the strains developed in the tunnel are due to nonuniform displacements of the ground.

Although large earthquakes are infrequent, microseismic activity in such countries as Japan is continuous. It is not surprising that full-scale structures such as underground tanks [32], underground structures [33], submerged tunnels [31, 34-36], pile foundations [37], and highway bridges [38] have been instrumented and their dynamic responses recorded during small earthquakes. In most of this work such methods as finite elements or lumped parameter formulations were subsequently used in attempts to correlate actual observations with numerically obtained results. The conclusions reached by the various researchers are that a) dynamic strains and stresses developed in structures are proportional to soil accelerations (although at high frequencies this proportionality is disturbed), b) axial strains in the buried structures are amplified at low frequencies,

c) bending strains increase at high frequencies, and d) natural frequencies of the soil layers are only slightly influenced by the presence of the structure.

ANALYTICAL METHODS

Analytic work on highly idealized representations of underground structures began in 1898 when Kirsch [39] investigated the stress concentration around a circular hole in an infinite elastic plaste under a uniaxial static stress. Dynamic stress concentration studies for two-dimensional structures by analytical methods were done in the early 1960s by Baron and his co-workers [40] and by others [41]. These investigators determined the dynamic stress and displacement fields produced around a circular cylindrical cavity in an infinitely extending elastic medium due to the passage of harmonic or transient waves. The case of a lined circular cylindrical cavity in an infinite medium was also considered [42, 43]. The diffraction of horizontally polarized shear waves (an anti-plane strain problem) by cylindrical and elliptical canyons on the surface of the half plane [44] and by a lined circular cylindrical tunnel buried in the half plane [45] has also been studied. Such techniques as the wave function expansion method or integral transforms along with the concept of separation of variables were employed. In a detailed review of the work done on dynamic stress concentration up until the year 1972, Pao and Mow [46] concluded that analytical methods of solution are possible only for problems with cylindrical, elliptical, spherical, or parabolic geometries and exhibiting elastic material behavior. Even very recent solutions to problems involving two-dimensional diffraction of elastic waves by inclusions, cavities, or shells in a half space [47, 48] are restricted to circular cylindrical geometries of the discontinuities. Therefore, for embedded structures of arbitrary shape under general dynamic disturbances, numerical methods of solution must be used.

It is of interest to note that in such linear solutions, dynamic stress concentration factors do not exceed the static counterpart by more than 15%. This is true for transient as well as harmonic excitations, the latter resulting in an upper bound solution for wave scattering problems. It can therefore be concluded that the resonance phenomenon observed in most dynamic systems when the frequency of excitation approaches the natural frequencies of the system is not present here [49, 50].

NUMERICAL METHODS

Two major categories of numerical techniques are currently being used for both linear and nonlinear dynamic structure-medium interaction analyses: approximate continuum and discrete (lumped parameter) models. The most widely used approximate continuum method at present is the finite element method (FEM). Its accuracy depends, in general, on element size, mesh dimensions, and assumed displacement functions [51, 52]. In principle, the FEM is a versatile technique when applied to structure-medium interaction problems because it can handle complex structural geometry, medium nonhomogeneities, large deformations, and complicated material behavior in both two and three dimensions. The finite element formulation of a problem results in a system of equations that can be solved by modal analysis, Fourier transform techniques, or step-by-step integration schemes.

The major deficiency of the FEM is that an infinite or semi-infinite medium is represented by a finite size model. The obvious remedy of using a very large mesh, as compared to structure, is uneconomical. Therefore, considerable effort has been directed toward obtaining non-reflecting or transmitting boundaries that are placed at the ends of the mesh to allow for energy radiation [53-55]. Transmitting boundaries can be either frequency dependent or independent and can absorb body waves, surface waves, or both. The best transmitting boundary model at present is valid for axisymmetric problems and reproduces the far field in a manner consistent with the FEM discretization of the core region [55]. A comparison of transmitting boundaries is available [56]. In the case of a wave propagation problem, an additional difficulty is that the motion at the boundaries of the mesh must be prescribed without interfering with the already placed transmitting boundaries.

The FEM can employ three-dimensional, axisymmetric, and two-dimensional solid elements. The first type results in enormous computation requirements that only a few researchers can afford. Therefore, at present the other two types of elements are often

used. Luco and Hadjian [57] found that, for nuclear power plants, a two-dimensional approximation of the three-dimensional problem results in considerable underestimation of the response.

The finite difference method (FDM) has also been employed for the solution of dynamic structure-medium interaction problems. For example, Ang and Newmark [58] determined the response of underground structures to surface blasts assuming elastic soil behavior. Ang and Chang [59] introduced elastic-perfectly plastic soil behavior using the Von Mises yield criterion in the same problem. Transmitting boundaries for finite difference or finite element meshes and time domain formulations have also been developed [60, 61]. Numerous commercial programs for separate or combined FEM and FDM analyses are currently available.

Nelson and Isenberg [62] and Nelson [63] used the FDM to model a large soil area surrounding a soil island that includes the embedded structure. The soil island is modeled by the FEM. The purpose of their three-dimensional and two-dimensional studies was to determine the effects of a powerful air blast on the embedded structure.

The interaction effects between parallel tunnels due to moving railway trains has been studied by a dynamic plane strain FEM [64]. Haupt [65] used a FEM in conjunction with what he terms an influence matrix to determine the effect of a protective obstacle in the propagation of surface waves. The near field ground motions from the San Fernando 1971 earthquake were modeled by dynamic plane strain finite elements in the frequency domain [66]. The seismic behavior of an underground reactor building using two-dimensional finite elements was reported in [67]. A general-purpose FEM program has been produced for structures embedded in multilayered linear viscoelastic soil systems under any combination of surface and inclined body waves by Lysmer and his co-workers [68].

Discrete or lumped models have competed successfully with approximate continuum methods in structure-medium interaction problems [69]. The key idea behind a lumped parameter approach is to determine value for the mass, stiffness, and damping coefficients that essentially represent the medium. Use of these coefficients, also known as impedance functions, effectively uncouples the structure from the medium -- with due consideration to the interaction phenomenon -- and allows for an efficient dynamic analysis of the structure alone. An impedance function I_{ij} is generally a particular reaction of the medium at boundary point i due to a prescribed type of displacement at boundary point j, with all other possible displacements of the medium boundary prescribed as zero. For a three-dimensional continuum there are, in general, three possible components of translational motion at a particular point and three analogous reactions. Exact expressions for impedance functions can be obtaine[illegible]or very few cases. In most instances, analytic e[illegible]s sions for these functions are obtained under r[illegible]ed boundary conditions, mostly by assuming c reactions under a given type of displacement [illegible]e zero (uncoupling). Finally, successful attempt[illegible] been made at obtaining impedance functions b[illegible] numerical methods as the FEM [55].

These ideas have found extensive use in foundation problems. For instance, dynamic stiffness and damping coefficients in complex form and as functions of frequency have been determined for the case of a rigid disc on an elastic half space [70, 71], the case of a rigid strip on an elastic half plane [72], the case of a partially embedded rigid hemispherical footing [73], and the case of a flat circular foundation supported on a layered medium [74].

Relative little work has been done for the case of flexible foundations. Some information is available. Lin [75] treated analytically the case of vertical and rocking harmonic motions of a flexible circular disc resting on a viscoelastic half space. Iguchi [76] used analytical means to approximately solve the problem of vertical motions of a long flexible rectangular mat under oblique seismic motions. Dasgupta [77] introduced a substructure deletion method for two-dimensional embedded structures in which both FEM and analytically obtained soil impedances are used. The subject of the dynamic analysis of surface and embedded foundations is extensive; a complete list of references to 1981 is available [78]. Impedance functions for a vertical pile embedded in a linearly elastic or viscoelastic layered medium and subjected to harmonic motions at its top have also been found [79].

Extension of these concepts to underground structures is hampered by the fact that the boundary value

problem for the analytic determination of the appropriate impedance functions is very difficult, even after some boundary conditions are relaxed. For instance, the low frequency oscillations of a rigid circular disc buried in and in bonded contact with a linear elastic medium was developed in the context of a mixed boundary-value problem associated with two equivalent half spaces [80].

The dynamic response of a tunnel has been investigated [31, 81, 82] under the strong simplifying assumption of modeling the tunnel as a beam on an elastic foundation, and by Hindy and Novak [83] who derived soil reactions from approximate considerations of static and dynamic continuum theories. In older work [13, 84], the response of foam-isolated buried tunnels to the passage of a plane compression wave was investigated; the soil-structure interaction was postulated a priori so as to uncouple the free field motions from the structure motions. The steady state axial and lateral vibrations of a soil-pipe system exhibiting Coulomb friction at the interface were recently studied [85] by modeling the pipe as a long elastic rod with the frictional stresses uniformly distributed around the circumference.

It should be emphasized that both categories of numerical methods will produce perfectly acceptable results in the hands of a skilled analyst. However, the methods themselves suffer from certain shortcomings. Firstly, the numerical integration formulas used with the FEM introduce some artificial damping in the system. Next, the radiation condition necessitates the use of transmitting boundaries the physical characteristics of which are not completely understood at present. The FDM has the same problems as the FEM; in addition, the incorporation of boundary conditions is a formidable task. Lumped parameter models are perfectly acceptable for rigid surface foundation problems. Great difficulties arise, however, in the analytic determination of appropriate compliances for problems involving embedded foundations or buried structures.

A more fruitful approach to problems of this kind appears to be one in which both the far (medium) and near (structure) fields are determined by suitable numerical methods. In this approach the geometric damping (infinite distance radiation condition) is automatically accounted for, and the coupling of the two fields in the form of interface compatibility can be established. This is indeed the case if the FEM is coupled with the boundary element method (BEM), or if only the BEM is used [86, 87].

The basis of the BEM is the application of Green's Theorem to the governing quasi-linear partial differential equations of the problem on the unknown variable. In addition, a fundamental or particular solution representing a point source field; i.e., a Green's function, is needed. This procedure results in a surface integral that applies only to the boundary of the problem's domain (for linear problems) and incorporates the boundary conditions directly. In contrast, both the FEM and the FDM require full domain discretization. Development of this methodology to engineering problems has resulted in excellent solution accuracy and numerical efficiency [87].

Two basic approaches for the solution of transient problems involving underground structures exhibiting linear elastic behavior by the BEM are a) solution of the problem in a Fourier transform [88-91] or a Laplace transform [92-95] domain by the BEM approaches followed by a numerical inverse transformation to obtain the response in the time domain; and b) time domain formulation and solution of the problem by BEM approaches in conjunction with step-by-step time integration schemes. This has been done for both antiplane strain [96] and plane strain [97, 98] cases. Relatively simple two-dimensional problems were solved using these methods: the case of buried unlined [89-91, 93, 97] or lined [91, 94] circular cylindrical cavities under longitudinal or transverse waves and the cases of buried square or horse-shoe shaped cylindrical cavities under longitudinal waves [89, 90].

The use of special restricted Green's functions defined for the half plane have enabled a number of researchers [99-101] to consider in the frequency domain the diffraction of horizontally polarized transverse (shear) waves by irregular surfaces (canyons), an anti-plane strain problem. Anti-plane strain cases in elastodynamics are essentially one-dimensional problems and are identical to the scalar wave propagation problem, which has been extensively investigated by workers in the field of acoustics and water waves. Dravinski [102] used a source method, which is similar to an indirect BEM, in conjunction with a Green's function to recover the displacement field around an alluvial semi-elliptic

valley under harmonic body and surface waves. Manolis and Beskos [95] employed kernel functions constructed from full plane fundamental solutions to investigate the transient response of a cavity in the half plane.

For foundation problems it is necessary to resort to integral equation formulations in order to obtain solutions to the mixed boundary-value problem; this problem is a result of the dynamic analysis of rigid three-dimensional foundations of arbitrary shape embedded in layered media. For instance, the recent development of efficient methods to calculate Green's functions for layered viscoelastic media [103, 104] makes possible the use of integral equation methods for the evaluation of impedance functions for such cases. These methods are also applicable to the computation of foundation input motion. The case of flexible foundations has been investigated [105-108]. These researchers combined the FEM used for the foundation plate with the contact soil stiffness obtained analytically via a Green's function approach; they studied numerically the dynamic response of foundations resting on an elastic half space.

The major shortcoming of the BEM is a lack of suitable Green's functions. This makes difficult the extension of the method to problems involving nonhomogeneous media. However, the dynamic version of the BEM cannot yet be considered an established problem solving tool.

The final item to be considered is selection of appropriate constitutive equations to model the geological medium in which the structure is embedded. In recent years a number of models for describing the behavior of soils under monotonic and cyclic loadings have been developed [109]. Most of these models are based on the theory of plasticity incorporating isotropic hardening (expansion of the yield surface) and kinematic hardening (translation of the yield surface). Models developed by Mroz [110], Prevost [111], and Dafalias and Herrmann [112] are difficult to use in practical problems because of the complexities of their formulation and the difficulties associated with identifying appropriate soil parameters. A better choice for problems of this kind seems to be the reflecting surface model of Pande and Pietruszczak [113], which is valid for monotonic or cyclic loading, has the flexibility to simulate pore pressure generation, and is easy to implement numerically. A formulation in terms of stress invariants is adopted; only one more experimental parameter in addition to those required for classical state models is required for complete description of the model.

CONCLUSION

From observations, experimental work, and results of both analytical theories and numerical methods reviewed herein, it is clear that no significant problems are experienced with underground structures during dynamic shaking if the materials behave elastically and if the relative deformations between soil and structure are small. Thus, from an engineering point of view, placing structures below the surface is safe.

REFERENCES

1. Baker, R.F., "The Use of Underground Space to Achieve National Goals," ASCE Underground Construction Research Council (1972).

2. Fairhurst, C., "Going under to Stay on Top," Underground Space, 1(2), pp 71-86 (1976).

3. O'Sullivan, J.J., Editor, Protective Construction in a Nuclear Age, Vol. I, McMillan (1961).

4. Abel, J.F., Mark, R., and Richards, R., "Stresses around Flexible Elliptic Pipes," Proc. ASCE, 99 (SM7), pp 509-526 (1973).

5. Krauthammer, T., "Re-evaluation of Test Results on Shallow-Buried Structures," Proc. 10th Intl. Conf. Soil Mech. Fndn. Engrg., Stockholm, pp 161-164 (1981).

6. Hall, P., Brondum-Nielsen, T., and Kivisild, H.R., "Deas Island Tunnel," Proc. ASCE, 83 (ST6), pp 1436-1 - 1436-44 (1957).

7. Kuesel, T.R., "Earthquake Design Criteria for Subways," Proc. ASCE, 95 (ST6), pp 1213-1231 (1969).

8. Newmark, N.M., "Earthquake Response Analysis of Reactor Structures," Proc. 1st Intl. Conf.

Struc. Mech. Reactor Tech., Berlin, W. Germany (1971).

9. Sakurai, A. and Takahasi, S., "Dynamic Stresses of Underground Pipelines during Earthquakes," Proc. 4th World Conf. Earthquake Engrg., II (B-4), pp 81-96 (1969).

10. Pratt, H.R., Hustrulid, W.A., and Stephenson, D.E., "Earthquake Damage to Underground Facilities," Report DP-1513, E.I. Du Pont de Nemours and Co., Savannah River Lab. (1978).

11. Bulson, P.S., "Dynamic Loading of Buried Tubes in Sand and Clay," Proc. Intl. Symp. Wave Propagation Dynam. Prop. Earth Matl., pp 305-314, Univ. of New Mexico Press (1967).

12. Allgood, J.R. and Carter, W.O., "Blast Induced Body Motions of Buried Structures with Footings," Proc. Intl. Symp. Wave Propagation Dynam. Prop. Earth Matls., pp 315-333, Univ. of New Mexico Press (1967).

13. Constantino, C.J. and Vey, E., "Response of Buried Cylinders Encased in Foam," Proc. ASCE, 95 (ST12), pp 1159-1177 (1969).

14. Yuan, H.F. and Walker, R.E., "The Investigation of a Simple Soil-Structure Interaction Model," Chap. 16, D.A. Howells et al (Eds.), Dynamic Waves in Civil Engineering, J. Wiley (1970).

15. Balsara, J.P., "Blast Loaded Buried Arches," Proc. ASCE, 96 (EMI), pp 1-16 (1970).

16. Young, D.F. and Murphy, G., "Dynamic Similitude of Underground Structures," Proc. ASCE, 90 (EM3), pp 111-133 (1964).

17. Denton, D.R. and Flathau, W.J., "Model Study of Dynamically Loaded Arch Structures," Proc. ASCE, 92 (EM3), pp 17-32 (1966).

18. Landon, G. and Stephens, J., "GRABS over Vertical Shelter Tests," E.H. Wang Civil Engrg. Res. Fac. Rept., Univ. of New Mexico (1980).

19. Gran, J.K., Bruce, J.R., and Colton, J.D., "Scale Modelling of Buried Reinforced Concrete Structures under Air-Blast Loading," H.G. Harris (Ed.), Dynamic Modeling of Concrete Structures, pp 125-143, ACI (1981).

20. Isenberg, J. and Wang, F., "Modeling, Loading, and Response of Vertical Shelters," Final Rept., Weidlinger Assoc., Menlo Park (1980).

21. Wong, F.S., "Transfer Function Development for Shallow-Buried Rectangular Boxes," U.S. Air Force Weapons Lab. Rept., Weidlinger Assoc. (1980).

22. Wong, F.S., "Transfer Function Development for Shallow-Buried Horizontal Cylinders," U.S. Air Force Weapons Lab. Rept., Weidlinger Assoc. (1980).

23. Maso, T., Takasaki, Y., Yamamoto, S., and Koori, Y., "Earthquake Response of a Nuclear Reactor Building Deeply Embedded in Soil," Trans. 5th Intl. Conf. Struc. Mech. Reactor Tech., K 7/1, Germany (1979).

24. Tanaka, H., Ohta, T., and Uchiyama, S., "Experimental and Analytical Studies of a Deeply Embedded Reactor Building Model Considering Soil-Building Interaction, Part I," Trans. 5th Intl. Conf. Struc. Mech. Reactor Tech., K 7/8, Germany (1979).

25. Mizuno, N., Moribe, I., Sugiyama, N., Tsushima, T., Kushida, H., and Tamaki, T., "Forced Vibration Test of BWR Type Nuclear Building Considering Soil Coupling Between Adjacent Buildings," Trans. 5th Intl. Conf. Struc. Mech. Reactor Tech., K 13/4, Germany (1979).

26. Tajima, H., Minowa, C., and Shimomura, Y., "Dynamic Response of a Large-Scale Shaking Table Foundation and Its Surrounding Ground," Proc. 6th World Conf. Earthquake Engrg., 2, pp 1516-1521, India (1977).

27. Kawamura, S., Kitazawa, K., Kani, N., and Hisano, M., "Vibration Tests of Many Types of Base and Building Models Set on Real Ground," Proc. 7th World Conf. Earthquake Engrg., 7, pp 535-542, Turkey (1980).

28. Palamaru, G., Covali, S., Sorceanu, I., and Hovici, M., "Experimental Investigations Re-

garding Soil-Underground Metrotype Structure Dynamic Interaction," Proc. 7th World Conf. Earthquake Engrg., 6, pp 395-402, Turkey (1980).

29. Kuribayashi, E. and Iwasaki, T., "Effects of Soil Deposits on Seismic Behavior of Prefabricated Highway Tunnels," Proc. 5th World Conf. Earthquake Engrg., 2, pp 2614-2623 (1974).

30. Sugimura, Y., Participation Factor of Horizontal Force Applied to Pile Foundation," Proc. 7th World Conf. Earthquake Engrg., 3, pp 443-450, Turkey (1980).

31. Okamoto, S. and Tamura, C., "Behavior of Subaqueous Tunnels during Earthquakes," Intl. J. Earthquake Engrg. Struc. Dynam., 1, pp 253-266 (1973).

32. Hamada, M. and Sato, S., "Behavior of Underground Tank during Earthquakes," 6th World Conf. Earthquake Engrg., 2, pp 1503-1508, India (1977).

33. Hamada, M., Yokoyama, M., and Sugihara, Y., "Earthquake Observation of Underground Structures and Aseismic Design," Proc. 7th World Conf. Earthquake Engrg., 6, pp 485-492, Turkey (1980).

34. Goto, Y., Ota, J., Sato, T., "On Earthquake Response of Submerged Tunnels," Proc. 5th World Conf. Earthquake Engrg., 2B (63), pp 579-582, Rome (1973).

35. Hamada, M., Akimoto, T., and Izumi, H., "Dynamic Stresses of Submerged Tunnel during Earthquakes," 6th World Conf. Earthquake Engrg., 2, pp 1509-1514, India (1977).

36. Hamada, M., Shiba, Y., and Ishida, O., "Earthquake Observation on Two Submerged Tunnels at Tokyo Port," A.S. Cakmak, A.M. Abdel Ghaffar, and C.A. Brebbia (Eds.), Soil Dynamics and Earthquake Engineering, pp 723-735, Balkema (1982).

37. Hamada, M. and Ishida, O., "Earthquake Observation and Numerical Analysis of Dynamic Strain of Foundation Pile," Proc. 7th World Conf. Earthquake Engrg., 3, pp 435-442, Turkey (1980).

38. Kawashima, K., "Soil-Structure Interaction of a Highway Bridge with Use of Recorded Strong-Motion Accelerations," Proc. 7th World Conf. Earthquake Engrg., 6, pp 81-88, Turkey (1980)

39. Kirsch, G., "Die Theorie der Elastizitat und die bedurfnisse der festigkeitslehre," VDI-Z, 42, pp 797-807 (1898).

40. Baron, M.L. and Matthews, A.T., "Diffraction of a Pressure Wave by a Cylindrical Cavity in an Elastic Medium," J. Appl. Mech., Trans. ASME, 28, pp 345-354 (1961).

41. Miklowitz, J., "Scattering of a Plane Elastic Compressional Pulse by a Cylindrical Cavity," Proc. 11th Intl. Congr. Appl. Mech., pp 469-483, Munich (1964).

42. Mow, C.C. and McCabe, W.L., "Dynamic Stresses in an Elastic Cylinder," Proc. ASCE, 89 (EM3), pp 21-40 (1963).

43. Garnet, H. and Pascal, J.C., "Transient Response of Circular Cylinder of Arbitrary Thickness in an Elastic Medium to a Plane Dilational Wave," J. Appl. Mech., Trans. ASME, 33, pp 521-531 (1966).

44. Wong, H.L. and Trifunac, M.D., "Scattering of Plane SH Waves by Semi-elliptical Canyon," Intl. J. Earthquake Engrg. Struc. Dynam., 3, pp 157-169 (1974).

45. Lee, V.W. and Trifunac, M.D., "Response of Tunnels to Incident SH Waves," Proc. ASCE, 105 (EM4), pp 643-659 (1979).

46. Pao, Y.H. and Mow, C.C., Diffraction of Elastic Waves and Dynamic Stress Concentration, Crane Russak (1972).

47. Scheidl, W. and Ziegler, F., "Interaction of Pulsed Rayleigh Surface Wave and a Rigid Circular Inclusion," J. Miklowitz and J.D. Achenbach (Eds.), Modern Problems in Elastic Wave Propagation, pp 145-170, J. Wiley (1978).

48. El-Akily, N. and Datta, S.K., "Response of a Circular Cylindrical Shell to Disturbances in a Halfspace," Intl. J. Earthquake Engrg. Struc. Dynam., 8, pp 469-477 (1980).

49. Datta, S.K., Shah, A.H., and El-Akily, N., "Dynamic Behavior of a Buried Pipe in a Seismic Environment," J. Appl. Mech., Trans. ASME, 49, pp 141-148 (1982).

50. Baron, M.L., Bleich, H.H., and Weidlinger, P., "Theoretical Studies on the Ground Shock Phenomena," Paper SR-19, The Mitre Corp. (1960).

51. Lysmer, J. and Kuhlmayer, R.L., "Finite Dynamic Model for Infinite Media," Proc. ASCE, 95 (EM4), pp 859-877 (1969).

52. Costantino, C.J., Miller, C.A., and Lufrano, L.A., "Soil-Structure Interaction Parameters from Finite Element Analysis," Nucl. Engrg. Des., 38, pp 289-302 (1976).

53. Lysmer, J. and Waas, G., "Shear Waves in Plane Infinite Structures," Proc. ASCE, 98 (EM1), pp 85-105 (1972).

54. White, W., Valliappan, S., and Lee, I.K., "Unified Boundary for Finite Dynamic Models," Proc. ASCE, 103 (EM5), pp 949-964 (1977).

55. Kausel, E., Roesset, J.M., and Waas, G., "Dynamic Analysis of Footings on Layered Media," Proc. ASCE, 101 (EM5), pp 679-693 (1975).

56. Roesset, J.M. and Ettouney, M.M., "Transmitting Boundaries: A Comparison," Intl. J. Numer. Anal. Methods Geomech., 1, pp 151-176 (1977).

57. Luco, J.E. and Hadjian, A.H., "Two-dimensional Approximations to the Three-Dimensional Soil-Structure Interaction Problem," Nucl. Engrg. Des., 31, pp 195-203 (1974).

58. Ang, A.H.S. and Newmark, N.M., "Computation of Underground Structural Response," Univ. of Illinois Report for Defense Atomic Support Agency (now Defense Nuclear Agency), DASA Rept. 1386, Washington (1963).

59. Ang, A.H.S. and Chang, G.C., "Numerical Calculation of Inelastic Plane Structure-Soil Interaction," Proc. Intl. Symp. Wave Propagation Dynam. Prop. Earth Matls., pp 393-410, Univ. of New Mexico Press (1967).

60. Clayton, R. and Engquist, B., "Absorbing Boundary Conditions for Acoustic and Elastic Wave Equations," Bull. Seismol. Soc. Amer., 67, pp 1529-1540 (1977).

61. Cundall, P.A., Kunar, R.R., Carpenter, P.C., and Marti, J., "Solution of Infinite Dynamic Problems by Finite Modeling in the Time Domain," Proc. 2nd Intl. Conf. Appl. Numer. Modeling, Spain (1978).

62. Nelson, I. and Isenberg, J., "Soil Island Approach to Structure/Media Interaction," C.S. Desai (Ed.), Numerical Methods in Geomechanics, pp 41-57, ASCE (1976).

63. Nelson, I., "Numerical Solution of Problems Involving Explosive Loadings," G. Gudehus, Ed., Dynamical Methods in Soil and Rock Mechanics, pp 239-297, Balkema (1978).

64. Valliappan, S., Chandrasekaran, V., and Lee, I.K., "Interaction between Tunnel Openings due to Vibration Effects," W. Wittke (Ed.), Numerical Methods in Geomechanics, pp 685-697, Balkema (1979).

65. Haupt, W.A., "Surface Waves in Non-homogeneous Halfspace," B. Prange (Ed.), Dynamical Methods in Soil and Rock Mechanics, pp 335-367, Balkema (1978).

66. Harding, S.T. and Perkins, D., "Dynamic Finite Element Modeling of Near Field Ground Motion from the San Fernando 1971 Earthquake," G.W. Borm (Ed.), Dynamical Methods in Soil and Rock Mechanics, pp 67-86, Balkema (1978).

67. Altes, J. and Koschmieder, I., "Influence of Embedment of a Reactor Building on the Seismic Behavior," G.W. Borm (Ed.), Dynamical Methods in Soil and Rock Mechanics, pp 227-237, Balkema (1978).

68. Masso, A.G., Chen, J.C., Pecker, A., and Lysmer, J., "Seismic Pressures on Embedded Structures in Different Seismic Environments," A.S. Cakmak, A.M. Abdel-Ghaffar, and C.A. Brebbia (Eds.), Soil Dynamics and Earthquake Engineering, pp 179-191, Balkema (1982).

69. Hadjian, A.H., Luco, J.E., and Tsai, N.C., "Soil-Structure Interaction: Continuum or Finite Element?" Nucl. Engrg. Des., 31, pp 151-167 (1974).

70. Veletsos, A.S. and Wei, Y.T., "Lateral and Rocking Vibration of Footings," Proc. ASCE, 97 (SM9), pp 1227-1248 (1971).

71. Luco, J.E. and Westmann, R.A., "Dynamic Response of Circular Footings," Proc. ASCE, 97 (EM5), pp 1381-1395 (1971).

72. Karasudhi, P., Keer, L.M., and Lee, S.L., "Vibration Motion of a Body on an Elastic Half-Plane," J. Appl. Mech., Trans. ASME, 35, pp 697-705 (1968).

73. Luco, J.E., "Torsional Response of Structures for SH Waves: The Case of Hemispherical Foundations," Bull. Seismol. Soc. Amer., 66, pp 109-123 (1976).

74. Luco, J.E., "Impedance Functions for a Rigid Foundation on a Layered Medium," Nucl. Engrg. Des., 31, pp 204-217 (1974).

75. Lin, Y.J., "Dynamic Response of Circular Plates Resting on Viscoelastic Half-Space," J. Appl. Mech., Trans. ASME, 45, pp 379-384 (1978).

76. Iguchi, M., "A Basic Study on the Behavior of Long Dimensional Size Buildings during Earthquakes," Proc. 6th World Conf. Earthquake Engrg., pp 1490-1495, India (1977).

77. Dasgupta, G., "Foundation Impedance Matrices for Embedded Structures by Substructure Deletion," Proc. ASCE, 106 (EM3), pp 517-523 (1980).

78. Johnson, J.J., "Soil-Structure Interaction: The Status of Current Analysis Methods and Research," Report prepared for U.S. Nuclear Regulatory Commission, Lawrence Livermore Lab. (1981).

79. Novak, M. and Aboul-Ella, F., "Impedance Functions of Piles in Layered Media," Proc. ASCE, 105 (EM3), pp 643-661 (1978).

80. Selvadurai, A.P.S. and Rahman, M., "A Note on Axisymmetric Oscillations of a Rigid Disc Inclusion Embedded in Isotropic Elastic Medium," Proc. Southeastern Mech. Conf., XVI, Huntsville, AL, pp 63-71 (1982).

81. Constantopoulos, J.V., Motherwell, J.T., and Hall, J.R., "Dynamic Analysis of Tunnels," W. Wittke (Ed.), Numerical Methods in Geomechanics, pp 831-840, Balkema (1979).

82. O'Rourke, M. and Wang, L.R.L., "Earthquake Response of Buried Pipeline," Earthquake Engineering and Soil Dynamics, pp 721-731, ASCE (1978).

83. Hindy, A. and Novak, M., "Earthquake Response of Underground Pipelines," Intl. J. Earthquake Engrg. Struc. Dynam., 7, pp 451-476 (1979).

84. Dawkins, W.P., "Analysis of Tunnel Liner-Packing Systems," Proc. ASCE, 95 (EM3), pp 679-693 (1969).

85. Akiyoshi, T. and Fuchida, K., "Soil-Pipeline Interaction through a Frictional Interface During Earthquakes," A.S. Cakmak, A.M. Abdel-Ghaffar, and C.A. Brebbia (Eds.), Soil Dynamics and Earthquake Engineering, pp 497-507, Balkema (1982).

86. Zienkiewicz, O.C., The Finite Element Method, McGraw-Hill (1977).

87. Banerjee, P.K. and Butterfield, R., Boundary Element Methods in Engineering Science, McGraw-Hill (1981).

88. Banaugh, R.P. and Goldsmith, W., "Diffraction of Steady Elastic Waves by Surfaces of Arbitrary Shape," J. Appl. Mech., Trans. ASME, 30, pp 589-597 (1963).

89. Niwa, Y., Kobayashi, S., and Azuma, N., "An Analysis of Transient Stresses Produced Around Cavities of Arbitrary Shape during the Passage of Travelling Waves," Mem. Fac. Engrg., Kyoto Univ., 37 (2), pp 28-46 (1975).

90. Kobayashi, S., Fukui, T., and Azuma, N., "An Analysis of Transient Stresses Produced around a Tunnel by the Integral Equation Method," pp 631-638, Proc. Symp. Earthquake Engrg., Japan (1975).

91. Niwa, Y., Kobayashi, S., and Fukui, T., "Applications of Integral Equation Method to Some Geomechanical Problems," C.S. Desai (Ed.), Numerical Methods in Geomechanics, pp 120-131, ASCE (1976).

92. Cruse, T.A. and Rizzo, F.J., "A Direct Formulation and Numerical Solution of the General Transient Elastodynamic Problem - I," J. Math. Anal. Appl., 22 (1), pp 244-259 (1968).

93. Manolis, G.D. and Beskos, D.E., "Dynamic Stress Concentration Studies by Boundary Integrals and Laplace Transform," Intl. J. Numer. Methods Engrg., 17, pp 573-599 (1981).

94. Manolis, G.D. and Beskos, D.E., "Dynamic Response of Line Tunnels by an Isoparametric Boundary Element Method," Comp. Meth. Appl. Mech. Engrg., 36, pp 291-307 (1983).

95. Manolis, G.D. and Beskos, D.E., "Dynamic Stress Field around a Cavity Embedded in a Halfplane by the Boundary Element Method," Intl. J. Earthquake Engrg. Struc. Dynam. (submitted).

96. Cole, D.M., Kosloff, D.D., and Minster, J.B., "A Numerical Boundary Integral Equation Method for Elastodynamics I," Bull. Seismol. Soc. Amer., 68, pp 1331-1357 (1978).

97. Niwa, Y., Fukui, T., Kato, S., and Fujiki, K., "An Application of the Integral Equation Method to Two-Dimensional Elastodynamics," Theoret. Appl. Mech., 28, pp 281-290, Univ. of Tokyo Press (1980).

98. Manolis, G.D., "A Comparative Study on Three Boundary Element Method Approaches to Problems in Elastodynamics," Intl. J. Numer. Methods Engrg., 19, pp 73-91 (1983).

99. Wong, H.L., Trifunac, M.D., and Westermo, B., "Effects of Surface and Sub-Surface Irregularities on the Amplitudes of Monochromatic Waves," Bull. Seismol. Soc. Amer., 67, pp 353-368 (1977).

100. Toki, K. and Sato, T., "Seismic Response Analysis of Surface Layer with Irregular Boundaries," Proc. 6th World Conf. Earthquake Engrg., pp 409-415, India (1977).

101. Kobori, T. and Shinozaki, Y., "Effects of Irregular Site Conditions on Structural Earthquake Response," Theoret. Appl. Mech., 27, Proc. 27th Japan Natl. Congr. Appl. Mech., pp 299-313, Univ. of Tokyo Press (1979).

102. Dravinski, M., "Scattering of Elastic Waves by an Alluvial Valley," Proc. ASCE, 108 (EM1), pp 19-31 (1982).

103. Apsel, R.J., "Dynamic Green's Function for Layered Media and Applications to Boundary-Value Problems," Ph.D. Thesis, Univ. of California, San Diego (1979).

104. Kausel, E., "An Explicit Solution for the Green Functions for Dynamic Loads in Layered Media," Research Report R81-13, MIT (1981).

105. Savidis, S.A. and Richter, T., "Dynamic Response of Elastic Plates on the Surface of the Half-Space," Intl. J. Numer. Anal. Methods Geomech., 3, pp 245-254 (1979).

106. Dominguez, J.M., "Response of Embedded Foundations to Travelling Waves," Research Report R-78-24, MIT (1978).

107. Ray, D., "3-D Halfspace Solution for Flexible Foundations," 3rd EMD/ASCE Spec. Conf., Austin, TX, pp 738-741, ASCE (1979).

108. Whittaker, W.L. and Christiano, P., "Harmonic Response of Plates on Elastic Half-Space," 3rd EMD/ASCE Spec. Conf., Austin, TX, pp 734-737, ASCE (1979).

109. Schofield, A. and Wroth, P., Critical State Soil Mechanics, McGraw-Hill (1968).

110. Mroz, Z., "On the Description of Anisotropic Work Hardening," J. Mech. Phys. Solids, 15, pp 163-175 (1967).

111. Prevost, J.H., "Plasticity Theory for Soil Stress-Strain Behaviour," Proc. ASCE, 104 (EM5), pp 1177-1194 (1978).

112. Dafalias, Y.F. and Herrmann, L.R., "Bounding Surface Formulation of Soil Plasticity," Chap. 10, G.N. Pande and O.C. Zienkiewicz (Eds.), Soil Mechanics: Transient and Cyclic Loads, J. Wiley (1982).

113. Pande, G.N. and Pietruszczak, S., "Reflecting Surface Model for Soils," Rept. CR406/82, Univ. College of Swansea (1982).

STABLE RESPONSE OF DAMPED LINEAR SYSTEMS

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Abstract. This paper updates and expands a previous review concerned with several aspects of the response of damped mechanical systems. Topics include asymptotic stability, oscillation conditions, forced response bounds, and eigenvalue localization. Considerable progress has been made on the last three topics but little on the first. Several simple new results are stated.

An earlier review [1] is updated and to some extent expanded in scope in this article. Four aspects of the response of time-invariant damped linear mechanical systems are treated; in particular

- conditions for asymptotic stability
- conditions for oscillation
- bounds on forced response
- localization of system eigenvalues

Comprehensive reviews of the properties of damped systems are available [2-10]. The scope here is narrow, but it is hoped that the discussion is thorough for the topics examined.

For the most part, the system under study for purposes of this review is discrete and symmetric and has positive definite coefficient matrices. However, there is some discussion of distributed parameter systems, asymmetric systems, and systems with indefinite damping.

The contributions of the investigations cited here find applications in a wide variety of design and analysis settings in which vibration control is central. For example, simple techniques have been sought to obtain optimal damper distribution for a large flexible structure [11].

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DAMPED LINEAR SYSTEMS

For the most part attention is given to the system described by

$$M\ddot{x} + D\dot{x} + Kx = f(t) \qquad (1)$$

$$\dot{x}(o) = x_o \qquad x(o) = x_o$$

where $x(t)$ is the n by 1 displacement vector; $f(t)$ is the n by 1 force vector, considered known. The symmetric matrices M, D, and K represent mass, damping, and stiffness, with M and K positive definite. Some comments are included on the case in which D is not positive definite and in which the system matrices are not symmetric.

To a lesser degree than for discrete systems work is reviewed on distributed parameter systems governed by

$$\ddot{x} + L_1[\dot{x}] + L_2[x] = f \qquad \text{on } \Omega \qquad (2)$$

$$B[x] = o \qquad \text{on } \partial\Omega$$

$$x(r, o) = x_o \qquad \dot{x}(r, o) = \dot{x}_o$$

The displacement vector x now depends on spatial coordinates represented by r; L_1, L_2, and B are partial differential linear spatial operators. The properties of L_1, L_2, and B, as well as the definition of the domain Ω and the boundary $\partial\Omega$ have been presented in detail [12].

ASYMPTOTIC STABILITY

The system represented by system equation (1) is called asymptotically stable if

$$|x| \to o \qquad \text{as} \qquad t \to o$$

whenever $f(t) = o$ for $t > o$. System equation (1) can without loss be reduced to the first order system [13]

$$\frac{dz}{dt} + Az = q(t) \tag{3}$$

where

$$z = \begin{Bmatrix} \dot{x} \\ \hline x \end{Bmatrix} \qquad A = \left[\begin{array}{c|c} M^{-1}D & M^{-1}K \\ \hline -I & o \end{array}\right] \qquad g = \begin{Bmatrix} f \\ \hline o \end{Bmatrix}$$

For asymptotic stability it is sufficient if

$$\mathrm{Re}(\lambda_j(A)) > o \tag{4}$$

for all $1 \leqslant j \leqslant 2n$ where λ_j is the jth eigenvalue of A. If (4) holds, A can be called a stable matrix.

Necessary and sufficient conditions for A to be stable are classical results associated with Lyapunov; they are briefly summarized here. Let C be any positive definite symmetric matrix. Then A is stable [14] if and only if there exists a positive definite Hermitian matrix P such that

$$AP + PA^T = C \tag{5}$$

C can be chosen as the identity matrix I.

The most direct way to verify the stability of A is to generate the numerical solution for equation (5) with C = I. Relatively efficient methods for doing so have been introduced [15, 16]; they exploit the fact that

$$PA - A^TP = S$$

S is antisymmetric. Other methods for verifying stability include the Routh-Hurwitz criterion [14] and methods based on matrix inners [14]. Unfortunately, the effort required to apply these tests is comparable to that of calculating the eigenvalues in the first place.

A sufficient condition for asymptotic stability of system equation (1) is that D be positive definite.

$$D > o$$

With K positive definite the Hamiltonian is a Lyapunov function. If D is semidefinite, asymptotic stability still holds if and only if the matrix

$$[D \mid DM^{-1}K \mid D(M^{-1}K)^2 \mid \ldots \mid D(M^{-1}K)^{n-1}]$$

has rank n [18].

If D is asymmetric, asymptotic stability need not result. In fact, if D is skew-symmetric and K is positive definite, the system is stable but not asymptotically stable. If, however, K is indefinite (or negative definite) and D is skew-symmetric, the system can still be stable; i.e., gyroscopic forces can be used to stabilize an unstable system. However, if positive definite damping is introduced, the system again becomes unstable. This is known as the Kelvin-Tait-Chetaev (KTC) theorem [17, 18]. If, in addition, the matrix K is asymmetric, a form of the KTC theorem still holds [19]. Namely, dissipation can cause instability in systems that are stable due to the presence of gyroscopic forces alone if the matrix K is symmetrizable; i.e., similar to a symmetric matrix [20].

Bounds on the eigenvalues of the solution matrix P in equation (5) have been derived [21-23] using matrix norm arguments; extremal properties of the eigenvalues of symmetric matrices have also been used [24, 25]. Unfortunately, no simple conditions have yet been derived on D less restrictive than positive definiteness. A generalized Lyapunov theorem has been introduced [14] that gives conditions similar to equation (5) for the eigenvlaues of A to be confined to a given region of the complex plane.

CONDITIONS FOR OSCILLATION

Several investigators have sought to extend the single-degree-of-freedom notions of overdamping, critical damping, and underdamping to large systems [26-30]. In particular, system equation (1) is underdamped if all of the eigenvalues of A have nonvanishing imaginary parts; it is overdamped if all of the imaginary parts vanish. Thus, an underdamped system oscillates in all modes; an overdamped system tends monotonically to the (asymptotic) state.

The problem is trivial if the system can be written as n independent modes. This occurs if [31]

$$DM^{-1}K = KM^{-1}D \tag{6}$$

in which case single-degree-of-freedom relations for critical damping apply to each mode. For example, the eigenvalues are all real if for $1 \leq j \leq n$,

$$d_j > 2\sqrt{k_j m_j}$$

System equation (1) with f = o has been transformed [30] to read

$$\ddot{y} + V\dot{y} + Wy = o \qquad (7)$$

with

$$V = M^{-1/2}DM^{-1/2} \qquad W = M^{-1/2}KM^{-1/2}$$

$$y = M^{1/2}x/(x^H Mx)^{1/2}$$

The superscript H denotes the Hermitian transpose.

The critical damping matrix Λ is defined by

$$\Lambda = 2W^{1/2} \qquad (8)$$

The system is underdamped if $\Lambda - V$ is positive definite, critically damped if $\Lambda - V = o$, and overdamped if $\Lambda - V$ is negative definite. The results have been used [32-33] to suggest design procedures. Several methods for computing the critical damping matrix have been presented [34-35].

An alternative method for designing overdamping into a system has been discussed [36]. A relation was derived for a critical surface in parameter space such that each eigenvalue corresponding to a damping rate lying below (above) the critical damping surface is complex (real).

The strongest results on overdamping have been obtained [13] by a simple extension of certain properties of symmetrizable matrices [20]. Specifically, the system equation (1) is overdamped if and only if A can be written as

$$A = PQ \qquad (9)$$

P and Q are positive definite and Hermitian. An elaborate argument using generalized inverses has been formulated in order to determine P and Q. No design applications of equation (8) have yet been reported.

Several contributions have involved oscillation conditions for distributed parameter systems. Relations analogous to equation (8) have been presented [37]; a critical surface approach has been developed [38].

BOUNDS FOR FORCED RESPONSE

It is well known that, if A is a stable matrix, system equation (1) exhibits bounded input-bounded output stability [39]. An apparently new estimate for the bound is presented below. Recall equation (3); the solution z is given [1] by

$$z = \exp(-At)z_o + \int_o^t \exp(-A(t-\tau))g(\tau)d\tau. \qquad (10)$$

Now A can be written as

$$A = S\Delta S^{-1}$$

where $\Delta = diag(\lambda_j(A))$. It follows that

$$\text{norm}(\exp(-At)) = \text{norm}(S\exp(-\Delta t)S^{-1})$$

$$\leq \kappa(S)\text{norm}(\exp(-\Delta t))$$

$$\leq \kappa(S)\exp(-\nu t)$$

where

$$\nu = \min_j \text{Re}(\lambda_j(A))$$

and $\kappa(S)$ is the condition number of S.

$$\kappa(S) = \text{norm}(S)\ \text{norm}(S^{-1}).$$

Suppose

$$\text{norm}(g) < \gamma \qquad t > o.$$

Then from equation (10)

$$\text{norm}(z) \leq \text{norm}(z_o) + \gamma\kappa(S)\int_o^t \exp[-\nu(t-\tau)]\,d\tau$$

$$\leq \text{norm}(z_o) + \gamma\kappa(S)/\nu \qquad (11)$$

A bounded response obtains for unbounded inputs such that

$$\text{norm}(g) \leq \gamma_1 + \gamma_2 \exp(\mu t)$$

where $\mu < \nu$.

For the most part, the relationship in (11) is not at all sharp. Better results have been obtained [40-44] for the special case in which f is oscillatory.

$$f = f_o \exp(i\omega t)$$

If equation (6) holds, single-degree-of-freedom relations immediately furnish [44]

$$\frac{\text{norm}(x)}{\text{norm}(f_o)} \leq \max_j \begin{cases} \frac{1}{k_j}, & \frac{k_j}{m_j} \leq \frac{d_j^2}{2m_j^2} \\ \frac{1}{d_j\sqrt{\frac{k_j}{m_j}}}, & \text{otherwise} \end{cases}$$

where m_j, d_j, and k_j denote the ordered eigenvalues of M, D, and K; (i.e., $m_1 \geq m_2 \geq \ldots \geq m_n$).

In the more general oscillatory input case in which equation (6) fails, a theorem [45] has been extended [43] to obtain the best possible bounds in terms of the extreme eigenvalues v_1, v_n, w_1, w_n of V and W introduced in equation (7). Namely,

$$\frac{\text{norm}(x)}{\text{norm}(f_o)} \leq \left[\min_{\Sigma} \min_{\omega>0} q(\omega; \Sigma)\right]^{-1}$$

where Σ stands for the parameters ρ_k, ρ_d, $\cos\theta$, $\cos\phi$ restricted such that

$$0 < \rho_k < 1 \qquad 0 < \rho_d < 1$$

$$-1 \leq \cos\theta \leq 1 \qquad -1 \leq \cos\phi \leq 1$$

The quantity q is defined by

$$\begin{aligned} q = {} & (k_n-\omega^2)^2 + 2\rho_k(k_n-\omega^2)(k_1-k_n)\cos^2\theta \\ & + \rho_k^2(k_1-k_n)^2\cos^2\theta + \omega^2 d_n^2 \\ & + 2\rho_d\omega^2 d_n(d_1-d_n)\cos^2\phi + \rho_d^2\omega^2(d_1-d_n)^2\cos^2\phi \\ & + 2\omega\rho_d\rho_k(k_1-k_n)(d_1-d_n)\cos\theta\cos\phi\sin\theta\sin\psi. \end{aligned}$$

LOCALIZATION OF SYSTEM EIGENVALUES

There has been a fair amount of interest in the question of approximate bounds on the real and imaginary parts of the eigenvalues of system equation (1). The Gershgoren theorem has been used [2, 46] to derive a circle in the complex plane containing the system eigenvalues. Systems satisfying equation (6) have been treated [27, 28]. In the commonly assumed case

$$D = \alpha M + \beta K$$

the influence of α and β on the eigenvalue locations has been extensively examined [47, 48]. Relatively sharp enclosure relations were obtained [49] using a shift in the eigenvalue spectrum together with the extremal properties of eigenvalues.

Some new and apparently improved results are presented here using the Cauchy-Schwartz inequality. From equation (8) the eigenvalues λ can be written as

$$\lambda = -y^H Vy \pm \sqrt{(y^H Vy)^2 - 4\, y^H Wy}.$$

Now by the Schwartz inequality,

$$y^H Wy \geq (y^H W^{1/2} y)^2$$

The imaginary part of λ is subject to

$$\begin{aligned} (\text{Im}\lambda)^2 &= 4y^H Wy - (y^H Vy)^2 \\ &\leq 4(y^H W^{\frac{1}{2}} y)^2 - (y^H Vy)^2 \\ &\leq [2y^H W^{\frac{1}{2}} y - y^H Vy]\,[2y^H W^{\frac{1}{2}} y + y^H Vy] \\ &\leq [y^H(2W^{\frac{1}{2}} - V)y]\,[y^H(2W^{\frac{1}{2}} + V)y] \\ &\leq \rho(2W^{\frac{1}{2}} - V)\,\rho(2W^{\frac{1}{2}} + V), \end{aligned} \qquad (12)$$

The spectral radius ρ is defined by

$$\rho(Q) = \max_j |\lambda(Q)|$$

Unfortunately, for the real part the Schwartz inequality is of no avail. Instead, the best results we have been able to derive are

$$\text{Re } \lambda \geq -\frac{v_1}{2} - \frac{1}{2} \max \left[|v_n^2 - 4w_1|^{\frac{1}{2}}, |v_1^2 - 4w_n|^{\frac{1}{2}} \right] \tag{13.1}$$

$$\text{Re } \lambda \leq \min [o, \phi] \tag{13.2}$$

where

$$\phi = -\frac{v_n}{2} + \frac{1}{2} \min \left[|v_n^2 - 4w_1|^{\frac{1}{2}}, |v_1^2 - 4w_n|^{\frac{1}{2}} \right]$$

Geometrically, the relationships given in (12, 13) define a rectangle in the complex plane that encloses the system eigenvalues.

CONCLUSION AND DISCUSSION

The literature has been reviewed on four aspects of the response of damped linear mechanical systems. Considerable progress has been made in the last several years on oscillation conditions, forced response bounds, and eigenvalue localization.

Unfortunately, progress has been disappointing on deriving simple conditions on system matrices, less restrictive than positive definiteness, under which asymptotic stability obtains. The potential of new results in vibration control settings is only beginning to be realized.

REFERENCES

1. Nicholson, D.W., "Stable Response of Damped Linear Systems," Shock Vib. Dig., 12 (6) (1980).
2. Lancaster, P., Lambda Matrices and Vibrating Systems, Pergamon Press (1966).
3. Müller, P.C., Stabilität und Matrizen, Springer-Verlag (1977).
4. Huseyin, K., Vibrations and Stability of Multiple Parameter Systems, Sijthoff and Noordhoff (1978).
5. Huseyin, K., "Vibrations and Stability of Mechanical Systems, Part I," Shock Vib. Dig., 8 (4) (1976).
6. Huseyin, K., "Vibrations and Stability of Mechanical Systems, Part II," Shock Vib. Dig., 12 (4) (1980).
7. Nayfeh, A. and Mook, D., Nonlinear Oscillations, Wiley Interscience (1979).
8. Rouche, N., Habets, D., and Laloy, M., Stability Theory by Lyapunov's Direct Method, Springer-Verlag (1977).
9. Atherton, D.P., Stability of Nonlinear Systems, Research Studies Press (1981).
10. Pusey, H., et al (eds.), An International Survey of Shock and Vibration Technology, Shock and Vibration Information Center (1981).
11. Wang, B.P. and Pilkey, W.D., "Optimal Damper Location in the Vibration Control of Large Space Structures," Dynamics and Control of Large Flexible Spacecraft, Proc. 3rd VPI/AIAA Symp. (1982).
12. Inman, D.J., "Oscillatory Damped Distributed Parameter Systems," Mech. Res. Comm. (1982).
13. Nicholson, D.W., "Overdamping of a Linear Mechanical System," (to appear in Mech. Res. Commun.).
14. Jury, E.I., Inners and Stability of Dynamic Systems, John Wiley and Sons, Inc. (1974).
15. Barnett, S. and Storey, C., Matrix Methods in Stability Theory, Barnes and Noble (1970).
16. Fawzy, I., "A Simplified Stability Criterion for Nonconservative Systems," J. Appl. Mech., Trans. ASME, 46 (1979).
17. Chetaev, N.J., The Stability of Motion, Pergamon Press (1971).
18. Willems, J.L., Stability Theory of Dynamical Systems, Nelson (1970).
19. Inman, D.J., "Dynamics of Asymmetric Nonconservative Systems," Paper 83-APM-4 (to appear in J. Appl. Mech., Trans. ASME).

20. Taussky, O., "Positive Definite Matrices and Their Role in the Study of the Characteristic Roots of General Matrices," Adv. Math., 2 (1968).

21. Shapiro, E.Y., "On the Lyapunov Matrix Equation," IEEE Trans. Auto Contr., AC-19 (1974).

22. Kwon, W.H. and Pearson, A.E., "A Note on the Algebraic Riccati Equation," IEEE Trans. Auto. Contr., AC-22 (1977).

23. Bialas, S., "On the Lyapunov Matrix Equation," IEEE Trans. Auto. Contr., AC-25 (1980).

24. Nicholson, D.W., "Eigenvalue Bounds for the Lyapunov and Riccati Matrix Equations," IEEE Trans. Auto. Contr., AC-26 (1981).

25. Nicholson, D.W., "Eigenvalue Bounds for $AB + BA^H$," Mech. Res. Commun. (1982).

26. Duffin, R.J., "A Minimax Theorem for Overdamped Networks," J. Ratl. Mech. Anal., 4 (1955).

27. Nicholson, D.W., "Eigenvalue Bounds for Damped Linear Systems," Mech. Res. Commun., 5 (1978).

28. Müller, P.C., "Oscillatory Damped Linear Systems," Mech. Res. Commun., 6 (1979).

29. Nicholson, D.W., "Comments on Damped Response in Linear Systems," Mech. Res. Commun., 6 (1979).

30. Inman, D.J. and Andry, A.N., "Some Results on the Nature of Eigenvalues of Discrete Damped Systems," J. Appl. Mech., Trans. ASME, 47 (1980).

31. Caughey, T.K. and O'Kelly, M.E.J., "Classical Normal Modes in Damped Linear Dynamic Systems," J. Appl. Mech., Trans. ASME, 32 (1965).

32. Inman, D.J. and Andry, A.N., "A Procedure for Designing Overdamped Lumped Parameter Systems," Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 52 (1982).

33. Ahmadian, M. and Inman, D.J., "A Computer Package for the Design of Damped Linear Multidegree of Freedom Systems," Proc., Symp. Adv. Trends Struc. Solid Mech., NASA, Washington, DC (Oct 1982).

34. Grey, J.A. and Andry, A.N., "A Simple Calculation for the Critical Damping Matrix of Linear Multidegree of Freedom Systems" (to appear in Mech. Res. Commun.).

35. Inman, D.J. and Orabi, I., "An Efficient Method for Computing the Critical Damping Condition" (to appear in J. Appl. Mech., Trans. ASME).

36. Beskos, D.E. and Boley, B.A., "Critical Damping in Linear Discrete Dynamic Systems," J. Appl. Mech., Trans. ASME, 47 (1980).

37. Inman, D.J. and Andry, A.N., "The Nature of Temporal Solutions of Damped Distributed Parameter Systems with Classical Normal Modes," ASME Paper 82-WA-APM-14 (to appear in J. Appl. Mech., Trans. ASME).

38. Beskos, D.E. and Boley, B.A., "Critical Damping in Certain Linear Continuous Dynamic Systems," Intl. J. Solids Struc., 47 (1981).

39. Müller, P.C., Forced Linear Vibrations, CISM Course 172, Springer-Verlag (1977).

40. Nicholson, D.W., "On the Forced Vibration of a Damped Linear System," Mech. Res. Commun., 6 (1979).

41. Müller, P.C., "Remarks on Vibrations of Damped Linear Systems," Mech. Res. Commun., 6 (1979).

42. Nicholson, D.W., "Bounds on the Forced Response of Damped Linear Systems," Mech. Res. Commun., 7 (1980).

43. Nicholson, D.W., "Response Bounds for Asymptotically Stable Time-Invariant Linear Dynamical Systems," IEEE Trans. Auto. Contr., AC-27 (1982).

44. Nicholson, D.W., "Forced Vibrations of a Large Damped Mechanical System," Shock Vib. Bull., U.S. Naval Res. Lab., Proc. 52 (1982).

45. Strang, G., "Eigenvalues of Jordan Products," Amer. Math. Month (1962).

46. Schneider, J., "Der Satz von Gerschgoren für Gedampfte Schwingungen," Z. angew. Math. Mech., 60 (1980).

47. Falk, S., "Eigenwerte Gedampfter Schwingungen bei Gultigkeit der Bequemlichkeitshypothese," Ing.-Arch., 47 (1978).

48. Schneider, J., "Beeinflüssung der Eigenwerte von Schwingungssystemen mit Modaler Dämpfung," Ing.-Arch., 48 (1979).

49. Schneider, J., "Einschliessung der Eigenwerte Modifizierter Gedampften Schwingungssysteme," Acta Mech., 40 (1981).

BOOK REVIEWS

DIGITAL SIGNAL PROCESSING AND TIME SERIES ANALYSIS

E.A. Robinson and M.T. Silvia
Holden-Day, Inc., San Francisco, CA
1979, 411 pp

The use of digital signal processing has required new methods and procedures. Both the analyst and designer of digital processing equipment must be familiar with a number of mathematical topics. As stated by the authors, "We have co-written the book in a form of a standard mathematics textbook in the following sense. The book is self-contained and all concepts are defined in mathematical terms as they are introduced." At times the mathematical format makes the book difficult to follow. The book contains 11 chapters, each of which is divided into a number of sections.

Chapter 1 considers complex variables and phasors, including Taylor and Laurent series. Chapter 2 discusses digital signals, finite differences, difference equations, and impulse response and convolution; a classification of digital systems is given. The classification is composed of autorecursive (AR), moving average (MA), and autorecursive moving average (ARMA). ARMA is seldom used in engineering applications but should become more important in future years.

Chapter 3 explains the transfer function via Taylor and Laurent series and Laplace Z transforms. The chapter concludes with a discussion of ARMA and its application to digital signal analysis.

Chapter 4 is the heart of the book. Fourier transform of digital signals is described – including Fourier transforms, finite Fourier transforms (FFT), and FFT. The reviewer believes that the authors should have included computer programs and applications in the FFT section.

Chapter 5 treats the relationship between analog and digital systems. Chapter 6 considers the design of MA, ARMA, and least squares design of MA filters.

Chapter 7 treats cepstrum, the Laplace Z transform, convolution, and reverse and inverse sequences of minimum delay. The reviewer believes that this chapter should have been placed after the sections on random processes, which are contained in Chapter 8. Stationary random processes, auto- and cross-correlation functions, and cumulative distributions are covered. Chapter 9 is concerned with spectral estimation -- periodogram, white noise, and gaussian and chi-square distributions. The cosine-squared window is considered, but no mention is made of Hanning, Parzen, Goodman, or cosine taper log windows. The reviewer believes the chapter is too brief to do justice to the general theory of random processes.

Chapter 10 focuses upon seismic deconvolution; i.e., exploration for oil and natural gases employing random processes. The concluding chapter briefly discusses speech deconvolution.

The authors have slanted the book toward electrical engineering and the design of special-purpose hardware for processing electrical signals. Information on applied time series analysis is minimal, and the book contains no computer programs.

This volume is not meant for casual reading. The reviewer believes that the authors should expand the book and incorporate the applied aspects of random processes. No mention is made of partial coherence or industrial applications of stochastic methods. The book should be supplemented by the volume entitled, ***Applied Time Series Analysis*** by Enochson and Otnes, which has been reviewed in the **Digest.**

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DIGITAL FOUNDATIONS OF TIME SERIES ANALYSIS -- THE BOX-JENKINS APPROACH

E.A. Robinson and M.T. Silvia
Holden-Day, Inc., San Francisco, CA
1979, 451 pp

The book consists of five chapters and two appendices.

Chapter 1 expresses time series analysis in terms of probability, random variables, arithmetic, and geometric smoothing. Chapter 2 treats the linear regression model. Some of the terms are used in stochastic analysis -- expected values, variance, covariance, Gaussian distributions, and least square estimates. Also included are tests of significance for regression coefficients, Gaussian multipliers, and variance and covariance for empirical regression coefficients. The chapter concludes with an interesting discussion of the condition of variance of error at a sample point and unbiased estimate of σ^2.

Chapter 3 has to do with multiple regression. Topics include matrix representation of sample observations, least square estimates in the multiple sense, tests of significance for regression functions and coefficients, and multiple and partial correlations. Other topics are orthogonality, sequential combination, and expectation of explained and unexplained sums of squares.

Chapter 4 is concerned with linear systems. The authors describe the convolution theorem and transforms, auto and cross correlation, feedback stability, approximate deconvolution, shaping and spiking filters, and rational approximations. The reviewer was disappointed that few practical applications were covered.

Chapter 5 treats the Box-Jenkins (BJ) approach to time series analysis. The authors introduce autoregression (AR) and moving average (MA). They combine the two and call the combination the mixed autoregressive moving average (ARMA) process. ARMA, which has only recently appeared in seismic analysis, permits greater flexibility in the fitting or modeling of time series. The chapter concludes with nonstationary processes and forecasting.

Ten appendices discuss methods for solving simultaneous equations, determinant and matrix theory, Cramer's rule, eigenvalues, eigenvectors, and orthogonal matrices.

This is one of the better books on time series analysis. The main shortcoming of this volume is the absence of both computer programs and applied types of problems. Inclusion of both would enhance the book. The reviewer does recommend this book to those interested in time series analysis. It is a good introduction to the more abstract aspects of the BJ approach.

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APPLICATIONS OF FUNCTIONAL ANALYSIS IN ENGINEERING

J.L. Nowinski
Plenum Press, New York, NY
1981, 304 pp, $37.50

The introduction states that the text is an attempt to close the present gap between books on the mathematical aspects of functional analysis and its applications to mechanics. In the last two decades researchers in various areas of applied mechanics have utilized successfully the methods of functional analysis in problems dealing with nonlocal continuum mechanics, nonlinear viscoelasticity, and finite element analysis. Increasing interest in applications has made it mandatory for the analytically-oriented engineering scientist to be formally exposed to the elements of functional analysis so that he will be able to use it quickly. The text under review fulfills that need admirably.

This monograph was written by a well-known researcher in mechanics whose recent contributions include the use of functional analysis. This strengthens his perspective as to what the aim of the book should be.

The first five chapters contain introductory material on basic topics. They cover the distinction between

physical and abstract spaces, basic vector algebra, dot product and length of a vector and generalization of these values to inner product and norm, linear independence, and Euclidean spaces of many dimensions. The next five chapters extend the concepts developed to infinite-dimensional spaces. The topics range from infinite-dimensional Euclidean spaces to Hilbert spaces and function spaces and their geometry. Applications are made to the bending and torsion of isotropic plates and bars, variational principles, and the theorems of Rayleigh-Betti and Clapeyron.

The final chapters are oriented toward applications; all of the examples are given under headings that pertain to the major topics of functional analysis. The methods involve finding bounds and establishing inequalities for various problems in elasticity, application of the hypercircle method, and the method of orthogonal projections. The direct methods of Rayleigh-Ritz and Trefftz in the calculus of variations are considered within the context of functional analysis, as are various other variational methods. The text ends with a brief chapter on the theory of distributions and Sobolev spaces.

Answers to a number of illustrative problems are provided; an extensive list of references will also help the reader to broaden the scope of his particular area of interest.

This book is not elementary and cannot be read without concentration on the subject matter. The patience of those readers who are willing to put forth the effort will be amply rewarded however. In the opinion of this reviewer, the information gained will far exceed the effort made to acquire it.

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INDUSTRIAL NOISE CONTROL

B. Fader
John Wiley & Sons, New York, NY
1981, 251 pp, $30.95

This book was written with the intent of educating those with a need to cope with immediate noise problems and "show you how to do that." In this reviewer's opinion the author has succeeded. He points out that this is not the first book written on noise control. The emphasis of the book is the working methods used in industrial noise control. The author mentions that the book is the result of suddenly being told that he was in charge of noise control and having to live up to that responsibility.

The chapter titles are:

1. What is Sound?
2. The Quality of Sound
3. Decibels
4. Instruments
5. Measurement
6. Absorption -- The General Idea
7. Using Absorption and Special Absorbers
8. Single-Wall Transmission Loss
9. Enclosures, Double Walls, Barriers
10. Mufflers, Silencers, Lined Ducts
11. Vibration Isolation
12. Damping
13. Bringing Things Together

The five five chapters cover the fundamentals necessary to understand noise and its control. These include instrumentation and their uses in making and interpreting measurements. Other basics include absorption, use of silencers, enclosures, and vibration isolation. The chapter on damping could be more complete, but it gives the reader information about the different types available as well as when damping is effective. The last chapter presents a case history of a noise control program undertaken to meet OHSA requirements.

The book is designed to give the reader the necessary information to get a job done with minimal theory and math. Typical situations are used to emphasize concepts. The basic theory that is presented is applied in many practical examples to reinforce key points. The English system of units is used throughout.

The book is interestingly written and easy to follow. It is recommended particularly for the novice who, with some practice, will be able to cope successfully with situations in which noise control is important. Even the more experienced professional should find this text useful and will want a copy.

V.R. Miller
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SHORT COURSES

DECEMBER

SCALE MODELING IN ENGINEERING DYNAMICS

Dates: December 5-9, 1983
Place: Washington, D.C.
Objective: The course will begin with a drop test demonstration of damage to model and prototype cantilever beams made from different materials. These tests help to introduce the concepts of similarity and of physical dimensions which are preliminary to any model analysis. Formal mathematical techniques of modeling will then be presented including the development of scaling laws from both differential equations and the Buckingham Pi Theorem. A number of sessions then follow wherein the instructors present specific analyses relating to a variety of dynamic vibrations and transient response problems. The problems are selected to illustrate the use of models as an analysis tool and to give examples of variations on different modeling techniques. Types of problems presented include impact, blast, fragmentation, and thermal pulses on ground, air and floating structures.

Contact: Wilfred E. Baker, Southwest Research Institute, P.O. Box 28510, San Antonio, TX 78284 - (512) 684-5111, Ext. 2303.

VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS, AND CALIBRATION

Dates: December 5-9, 1983
Place: Santa Barbara, California
Dates: February 6-10, 1984
Place: Santa Barbara, California
Dates: March 5-9, 1984
Place: Washington, D.C.
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis; also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos Street, Santa Barbara, CA 93105 - (805) 682-7171.

JANUARY

LECTURE/TRAINING COURSE ON NAVAL SHOCK

Dates: January 9-13, 1984
Place: San Diego, CA
Objective: Combat survivability is a key issue in the design of naval ships. Current DoD policy highlights survivability as an essential requirement in the ship acquisition process. The wars in South East Asia, the Middle East and, recently, in the Falkland Island conflict accentuated the need for combat survivability. Since shock induced by various weapons is a major and highly destructive weapon effect, design for survival under shock is a vital part of the ship survivability process. Hence, under present Navy policy, all mission-essential equipment must qualify to rigorous shock hardening requirements. Naval Systems Commands and Laboratories, shipbuilders and equipment suppliers all play a role in the shock hardening process. If you work for the Navy, you may be involved in the implementation and verification of the Navy shock requirements, or you may be responsible for the purchase of electronic or weapon systems that must be shock qualified. As an employee of a major shipbuilder or a Naval equipment supplier, you may be faced with broad and/or specific aspects of Naval shock design. This lecture/training course has been developed to help engineers, scientists, Naval architects and others understand and effectively deal with the U.S. Navy's ship shock hardening requirements. If you are faced with ship shock problems, participation in this course should

increase your value to your organization and enhance your own career advancement.

Contact: Henry C. Pusey or Maurisa Gohde, NKF Engineering Associates, Inc., 8150 Leesburg Pike, Suite 700, Vienna, VA 22180 - (703) 442-8900.

MACHINERY VIBRATION ENGINEERING

Dates: January 24-27, 1984
Place: Houston, Texas
Dates: July 17-20, 1984
Place: Oak Brook, Illinois
Dates: November 27-30, 1984
Place: Washington, D.C.
Objective: Techniques for the solution of machinery vibration problems will be discussed. These techniques are based on the knowledge of the dynamics of machinery; vibration measurement, computation, and analysis; and machinery characteristics. The techniques will be illustrated with case histories involving field and design problems. Familiarity with the methods will be gained by participants in the workshops. The course will include lectures on natural frequency, resonance, and critical speed determination for rotating and reciprocating equipment using test and computational techniques; equipment evaluation techniques including test equipment; vibration analysis of general equipment including bearings and gears using the time and frequency domains; vibratory forces in rotating and reciprocating equipment; torsional vibration measurement, analysis, and computation on systems involving engines, compressors, pumps, and motors; basic rotor dynamics including fluid film bearing characteristics, critical speeds, instabilities, and mass imbalance response; and vibration control including isolation and damping of equipment installation.

Contact: The Vibration Institute, 101 West 55th Street, Clarendon Hills, IL 60514 - (312) 654-2254.

FEBRUARY

MACHINERY VIBRATION ANALYSIS

Dates: February 21-24, 1984
Place: San Francisco, California
Dates: May 15-18, 1984
Place: Nashville, Tennessee
Dates: August 14-17, 1984
Place: New Orleans, Louisiana
Dates: November 13-16, 1984
Place: Cincinnati, Ohio
Objective: In this four-day course on practical machinery vibration analysis, savings in production losses and equipment costs through vibration analysis and correction will be stressed. Techniques will be reviewed along with examples and case histories to illustrate their use. Demonstrations of measurement and analysis equipment will be conducted during the course. The course will include lectures on test equipment selection and use, vibration measurement and analysis including the latest information on spectral analysis, balancing, alignment, isolation, and damping. Plant predictive maintenance programs, monitoring equipment and programs, and equipment evaluation are topics included. Specific components and equipment covered in the lectures include gears, bearings (fluid film and antifriction), shafts, couplings, motors, turbines, engines, pumps, compressors, fluid drives, gearboxes, and slow-speed paper rolls.

Contact: The Vibration Institute, 101 West 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

DYNAMIC BALANCING SEMINAR/WORKSHOP

Dates: February 22-23, 1984
March 21-22, 1984
April 18-19, 1984
May 23-24, 1984
Place: Columbus, Ohio
Objective: Balancing experts will contribute a series of lectures on field balancing and balancing machines. Subjects include: field balancing methods; single, two and multi-plane balancing techniques; balancing tolerances and correction methods. The latest in-place balancing techniques will be demonstrated and used in the workshops. Balancing machines equipped with microprocessor instrumentation will also be demonstrated in the workshop sessions, where each student will be involved in hands-on problem-solving using actual armatures, pump impellers, turbine wheels, etc., with emphasis on reducing costs and improving quality in balancing operations.

Contact: R.E. Ellis, IRD Mechanalysis, Inc., 6150 Huntley Rd., Columbus, OH 43229 - (614) 885-5376.

MARCH

MEASUREMENT SYSTEMS ENGINEERING
Dates: March 12-16, 1984
Place: Phoenix, Arizona

MEASUREMENT SYSTEMS DYNAMICS
Dates: March 19-23, 1984
Place: Phoenix, Arizona
Objective: Program emphasis is on how to increase productivity and cost-effectiveness for data acquisition groups in the field and in the laboratory. The program is intended for engineers, scientists and managers of industrial, governmental and educational organizations who are concerned with planning, executing, or interpreting experimental data and measurements. The emphasis is on electrical measurements of mechanical and thermal quantities.

Contact: Peter K. Stein, Director, Stein Engineering Services, Inc., 5602 East Monte Rosa, Phoenix, AZ 85018 - (602) 945-4603/946-7333.

APRIL

ROTOR DYNAMICS
Dates: April 30 - May 4, 1984
Place: Syria, Virginia
Objective: The role of rotor/bearing technology in the design, development and diagnostics of industrial machinery will be elaborated. The fundamentals of rotor dynamics; fluid-film bearings; and measurement, analytical, and computational techniques will be presented. The computation and measurement of critical speeds vibration response, and stability of rotor/bearing systems will be discussed in detail. Finite elements and transfer matrix modeling will be related to computation on mainframe computers, minicomputers, and microprocessors. Modeling and computation of transient rotor behavior and nonlinear fluid-film bearing behavior will be described. Sessions will be devoted to flexible rotor balancing including turbogenerator rotors, bow behavior, squeeze-film dampers for turbomachinery, advanced concepts in troubleshooting and instrumentation, and case histories involving the power and petrochemical industries.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, 101 W. 55th Street, Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254.

NEWS BRIEFS: news on current and Future Shock and Vibration activities and events

Call for Papers

XVIth INTERNATIONAL CONGRESS OF THEORETICAL AND APPLIED MECHANICS
August 19-25, 1984
Lyngby, Denmark

The United States National Committee on Theoretical and Applied Mechanics has announced plans for the XVIth International Conference of Theoretical and Applied Mechanics. The Congress encompasses the entire field of analytical, solid, and fluid mechanics, including applications.

There will be an opening lecture and a closing lecture, as well as a number of invited sectional lectures of more specialized nature. The International Congress Committee has invited a number of distinguished scientists to present these lectures.

Up to 540 contributed papers will be presented as lectures (approximately 270) and in poster/discussion sessions.

Within the framework of the Congress the following three special topics will receive particular attention:

- micro-level studies of properties of multi-component media
- marine-structure wave interaction, and
- development of chaotic behaviour in dynamical systems

Each of these topics is interdisciplinary in the sense that it is intended to cover solid as well as fluid aspects. Convenors have been appointed to coordinate the lectures and other activities of each special session. Initial lectures are intended to have an instructional element.

Procedures for submitting papers may be obtained from: Prof. Richard T. Shield, 212 Talbot Laboratory, Dept. of Theoretical and Applied Mechanics, University of Illinois, Urbana, IL 61801.

The USNC/TAM has been charged with the task of evaluating all U.S. contributed papers. The evaluation is in the hands of a committee chaired by Prof. Shields. The committee will be assisted by a fairly large number of reviewers representing diverse areas of mechanics of fluids and solids. The resulting evaluation will then be used by the International Papers Committee as a guide for the final selection. Authors will be notified in May 1984 about the decision regarding their papers.

The USNC/TAM is also making an effort to obtain funds in order to provide some travel assistance for U.S. participants in the International Congress in Lyngby. Further details regarding this will be announced at a later date. Participants desiring information on travel support should notify: Mr. Richard Y. Dow, Staff Officer, USNC/TAM, National Research Council, 2101 Constitution Avenue, N.W., Washington, DC 20418.

Call for Papers

VIBRATION DAMPING WORKSHOP
February 27-29, 1984
Queen Mary Hotel
Long Beach, California

The Vibration Damping Workshop will provide a forum for the latest state-of-the-art technology as well as selected tutorial information. Viscoelastic property measurement and representation, high-damped-metals, friction damping, damping in composites, analysis and design, applications, experimental verification, controls-structure-interaction, and payoff/benefits are topics to be covered. The status of U.S. Air Force funded contracts on the Damping Design Guide, Passive and Active Control of Space Structure (PACOSS) and Reliability of Satellite Equipment in a Vibroacoustic Environment (RELSAT) contracts will be reviewed.

Abstracts/papers and the desired length of time for presentation should be sent to the Sponsor:

Dr. Lynn Rogers, AFWAL/FIBA, Area B, Bldg. 45, Room 257, Wright-Patterson AFB, OH 45433 - (513) 255-5664.

Registration packets are available from the Administrative Chairman: Mrs. Audrey G. Sachs, University of Dayton Research Institute, KL 542, 300 College Park Avenue, Dayton, OH 45469 - (513) 229-2919.

Call for Papers

1984 DESIGN AUTOMATION CONFERENCE
October 7-11, 1984
Cambridge, Massachusetts

The 10th Design Automation Conference will be held in conjunction with the 18th Mechanisms Conference on October 7-11, 1984 at the Hyatt Regency Hotel in Cambridge, Massachusetts. These conferences are sponsored by the Design Engineering Division of the American Society of Mechanical Engineers.

The ASME Design Automation Committee invites authors to submit papers in the broad areas of design and automation including:

- man-machine interaction
- computer graphics and drafting
- optimization and numerical methods
- mechanical design applications including social, economic, and legal aspects
- CAD/CAM systems
- hardware/software systems evaluation
- finite element analyses
- intelligent machines and robotics

Four copies of each manuscript and the original drawings must be submitted for review by February 15, 1984. Papers accepted for the conference and published as ASME pamphlets will be preprinted from final mats prepared by the authors. These standard mats will be provided to authors soon after acceptance of their papers. Each accepted paper will also be reviewed for possible publication in the ***ASME Journal of Mechanisms, Transmissions and Automation in Design*** and/or ***Mechanical Engineering.***

Manuscripts should be submitted to: Professor Panos Papalambros (Papers Review Chairman), Mechanical Engineering and Applied Mechanics, The University of Michigan, Ann Arbor, MI 48109 - (313) 763-1046.

The deadline for international contributions is January 15, 1984.

Interested parties are encouraged to forward suggestions for session themes and/or panel discussion topics to the above committee member.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of publications abstracted are not available from SVIC or the Vibration Institute, except those generated by either organization. Government Reports (AD-, PB-, or N-numbers) can be obtained from NTIS, Springfield, Virginia 22151; Dissertations (DA-) from University Microfilms, 313 N. Fir St., Ann Arbor, Michigan 48106; U.S. Patents from the Commissioner of Patents, Washington, DC 20231; Chinese publications (CSTA-) in Chinese or English translation from International Information Service Ltd., P.O. Box 24683, ABD Post Office, Hong Kong. In all cases the appropriate code number should be cited. All other inquiries should be directed to libraries. The address of only the first author is listed in the citation. The list of periodicals scanned is published in issues 1, 6, and 12.

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MECHANICAL SYSTEMS

ROTATING MACHINES

(Also see Nos. 2145, 2270, 2314, 2323, 2324, 2354)

83-2135

Instability of Rotors in Fluid Film Bearings

J.S. Rao

Stress Technology, Inc., Rochester, NY, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (5), pp 274-279 (July 1983) 9 figs, 10 refs

Key Words: Rotors, Fluid-film bearings, Whirling, Oil whip phenomena

This paper is concerned with instability of a rotor that arises due to fluid film forces of a journal bearing. The half frequency whirl and the resulting oil whip phenomena is explained by a consideration of flow balance in a bearing which loses the load carrying capacity. The threshold instability criterion for a rigid rotor in plain cylindrical bearings is given in the form of a chart by obtaining the solution of equations of motion with the corresponding spring and damping coefficients. Both translatory and conical whirls are considered. The analysis is then presented for a flexible rotor and a simple procedure is given to obtain the instability threshold speed based on the rigid rotor criterion.

83-2136

Free Wake Techniques for Rotor Aerodynamic Analysis. Volume 1: Summary of Results and Background Theory

R.H. Miller

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. ASRL-TR-199-1, NASA-CR-166434, 48 pp (Dec 1982)

N83-19711

Key Words: Rotors, Aerodynamic loads, Fluid-induced excitation

Results obtained during the development of a consistent aerodynamic theory for rotors in hovering flight are discussed. Methods of aerodynamic analysis were developed which are adequate for general design purposes until such time as more elaborate solutions become available, in particular solutions which include real fluids effects.

83-2137

Free Wake Techniques for Rotor Aerodynamic Analysis. Volume 2: Vortex Sheet Models

A. Tanuwidjaja

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. NASA-CR-166435, 162 pp (Dec 1982)

N83-19712

Key Words: Rotors, Aerodynamic loads, Fluid-induced excitation

Results of computations are presented using vortex sheets to model the wake and test the sensitivity of the solutions to various assumptions used in the development of the models. The complete codings are included.

83-2138

Free Wake Techniques for Rotor Aerodynamic Analysis. Volume 3: Vortex Filament Models

M. Brower

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. NASA-CR-166436, 69 pp (Dec 1982)

N83-19713

Key Words: Rotors, Aerodynamic loads, Fluid-induced excitation

Results obtained using a vortex filament model, as opposed to sheets are discussed, against using various modeling techniques and including the computer codings.

83-2139

Forward Velocity Effects on Fan Noise and the Influence of Inlet Aeroacoustic Design as Measured in the NASA Ames 40 x 80 Foot Wind Tunnel

R.G. Holm, L.E. Langenbrunner, and E.O. McCann

General Electric Co., Cincinnati, OH, Rept. No. NASA-CR-166461, 188 pp (July 1981)

N83-20709

Key Words: Fans, Turbofans, Fan noise, Noise reduction

The inlet radiated noise of a turbofan engine was studied. The principal research objectives were to characterize or suppress such noise with particular regard to its tonal characteristics. The major portion of this research was conducted using ground-based static testing without simulation of aircraft forward speed or aircraft installation-related aeroacoustic effects.

83-2140

On the Transient Interaction of Centrifugal Compressors and Their Piping Systems

C.R. Sparks

Southwest Res. Inst., San Antonio, TX, ASME Paper No. 83-GT-236

Key Words: Compressors, Centrifugal compressors, Piping systems

This paper provides some new and significant findings on the dynamic interaction of centrifugal compressors with piping systems and describes the basic phenomena underlying these interactions.

83-2141

Component Synthesis of Multi-Case, Rotating Machinery Trains by the Generalized Receptance Approach

A.B. Palazzolo, B.P. Wang, and W.D. Pilkey

Southwest Res. Inst., San Antonio, TX, ASME Paper No. 83-GT-229

Key Words: Rotating machinery, Component mode synthesis

A method is presented for computing the eigenvalues of multicase, coupled, rotating machinery trains. The method is based on a synthesis technique that uses generalized receptance formulas previously derived by the authors. These formulas improve the accuracy of the computed receptances when only an incomplete set of modes is available.

RECIPROCATING MACHINES

(Also see No. 2339)

83-2142

Transient Analysis of a Three Phase Induction Motor with Single Phase Supply

S.S. Murthy, G.J. Berg, B. Singh, C.S. Jha, and B.P. Singh

Univ. of Calgary, Calgary, Canada, T2N 1N4, IEEE Trans., Power Apparatus Syst., PAS-102 (1), pp 28-37 (Jan 1983) 11 figs, 2 tables, 9 refs

Key Words: Induction motors, Transient response

The transient behavior of a three phase induction motor operating with single phase supply and using capacitors as phase converter is considered. Instantaneous symmetrical components are used in modeling the motor with different stator connections, including the external capacitor. Digital simulation studies are carried out for the system considered and results are presented and discussed.

83-2143

Measurement of the Acoustic Internal Source Impedance of an Internal Combustion Engine

D.F. Ross and M.J. Crocker

Ray W. Herrick Labs., School of Mech. Engrg., Purdue Univ., West Lafayette, IN 47907, J. Acoust. Soc. Amer., 74 (1), pp 18-27 (July 1983) 23 figs, 36 refs

Key Words: Internal combustion engines, Acoustic impedance, Test facilities, Measurement techniques, Experimental test data

The standing wave tube technique has been adapted to measure the acoustic internal source impedance of an internal combustion engine. In order to implement this technique an extensive experimental facility was designed and constructed and simple test cases were evaluated for validity. In addition an adaptation of the standing wave tube method incorporating a random signal as the external driver sound source and digital data analysis techniques were introduced to reduce the experimental difficulty and time consumption.

83-2144

Noise Analysis and Control in Fluid Power Systems. Part 5: Noise Radiated from Components – Piston and Gear Pumps

H.R. Martin

Univ. of Waterloo, Waterloo, Ontario, Canada, Hydraul. Pneumat., 36 (6), pp 60-64 (June 1983) 5 figs, 6 refs

Key Words: Pumps, Noise generation, Sound propagation

All positive displacement pumps move discrete blocks of fluid from the inlet port to the outlet port of the pump. As this process is periodic in nature, most of the radiated noise energy is associated with the fundamental pumping frequency and its harmonics. This part of the noise is radiated partly through the pump casing and partly as pressure fluctuations in the delivery line. In addition, broadband noise from flow turbulence is superimposed on the periodic noise.

83-2145

A Theoretical and Experimental Study of Hydraulic Power Supplies Using Pressure-Compensated Pumps, Their Influence on Servosystem Dynamic Response, and Their Utilization in Energy-Saving Configurations

A. Pery

Ph.D. Thesis, Ohio State Univ., 499 pp (1983)
DA8311788

Key Words: Pumps, Hydraulic systems, Servomechanisms, Computer programs, Frequency domain method, Time domain method

Most valve controlled servosystem analyses assume constant supply pressure. When servo transients are large and fast enough, a pressure compensated pump type of supply, without accumulator, can no longer maintain reasonably constant supply pressure and pump dynamics become significant. Combined pump/servosystem dynamics was studied analytically and experimentally tested. Both linearized and nonlinear system models were formulated. A useful subsystem modeling technique was developed. Computer programs were developed in both time domain and frequency domain. Experimentally, step response performance was evaluated in terms of controlled variable maximum overshoot, frequency of oscillations and time to peak. Frequency tests were performed investigating three transfer functions.

POWER TRANSMISSION SYSTEMS

83-2146

Dynamic Behavior of Hydraulic Magnets under Service Conditions (Dynamisches Verhalten von Hydraulikmagneten unter Betriebsbedingungen)

M. Seitz

TH Ilmenau, Sektion Gerätetechnik, Germany, Feingerätetechnik, 32 (5), pp 199-202 (1983) 11 figs, 3 refs
(In German)

Key Words: Hydraulic systems, Power transmission systems

A number of hydraulic systems are employed for driving and control of machinery. The dynamic response of hydraulic magnets during starting and service conditions is presented and the possibilities for the determination of hydraulic forces are discussed.

ELECTROMECHANICAL SYSTEMS

(See Nos. 2248, 2249, 2250)

MATERIALS HANDLING EQUIPMENT

83-2147

Noise Reduction at Vibrating Feeders (Lärmminderung an einem Vibrationsförderer)

G. Rau

Maschinenbautechnik, 32 (5), pp 219-222 (1983) 9 figs, 3 tables, 3 refs
(In German)

Key Words: Conveyors, Vibratory techniques, Noise reduction

The electromagnetic excitation of vibrating feeders causes noise with a low freuqency which is predominantly emitted from the coating and feeding container. If the feeding materials (metal parts) strike the vibrator conveyor a high-frequency noise is additionally generated. The optimization of the tested different noise control measurements result in a noise reduction of the feeder by about 26 dB(A).

83-2148

Transient Torque Produced in Main Shaft of Electric Hoist During Motor Start-Up and Emergency Brake Operations

A. Futakawa, N. Muramatsu, K. Takeya, and F. Ishida

Central Res. Lab., Mitsubishi Electric Corp., Amagasaki, Hyogo, Japan, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 17-23 (Jan 1983) 13 figs, 4 refs

Key Words: Hoists, Shafts, Transient response, Start-up response, Braking effects

The purpose of this study is to clarify the generation mechanism of the transient torque produced in the main shaft of an electric hoist. A mathematical model with three degrees of freedom is proposed for the transient motion analysis of an electric hoist when lifting a weight and application of an emergency brake. A technique is developed for measuring the transient torque of a main shaft and the transient tension of a wire rope. Comparing theoretical with experimental results, the generation mechanism of the transient torque produced in the main shaft of the electric hoist is clarified. The effects of the torsional stiffness and rotating speed of the

main shaft, and the emergency brake torque on the transient torque produced in the main shaft are discussed. Dynamic load factors for the wire rope are also discussed.

STRUCTURAL SYSTEMS

BRIDGES

83-2149
Methodology for the Dynamic Analysis of Bridge/Abutment/Backfill Systems Subjected to Traveling Seismic Waves
B.D. Dendrou
Agbabian Associates, El Segundo, CA, Rept. No. AA-R-8113-5470, 254 pp (Mar 1983)
PB83-189357

Key Words: Bridges, Seismic excitation, Seismic waves, Moving loads

This report describes an advanced methodology (BASSIN), for analyzing traveling seismic wave effects on the dynamic response of an arbitrarily-configured, elastic bridge system. A substructuring approach has been used to formulate BASSIN; the bridge system is represented using a three-dimensional finite element model, and the underlying soil is depicted using a boundary element approach based on elastic half-space theory.

BUILDINGS

83-2150
Alternative Methods for Hazard Reduction in Unreinforced Masonry Buildings
M. Durkin
Woodland Hills, CA, Rept. No. NSF/CEE-82098, 46 pp (Dec 1982)
PB83-186858

Key Words: Buildings, Masonry, Earthquake damage

This report concerns the development of alternative hazard reduction strategies for unreinforced masonry buildings. The major characteristics and evolutionary trends of different types of unreinforced masonry buildings in different urban contexts are summarized. Major damage patterns from past U.S. earthquakes are identified, as well as factors such as configuration, use, location, and construction technology which might affect the seismic performance of different subcategories of unreinforced masonry buildings.

83-2151
Cladding-Structure Interaction in Highrise Buildings
B.J. Goodno, J.I. Craig, M. Meyyappa, and H. Palsson
Georgia Inst. of Tech., Atlanta, GA, Rept. No. NSF/CEE-83003, 618 pp (Jan 1983)
PB83-195891

Key Words: Buildings, Multistory buildings, Cladding effect, Seismic response

The potential lateral stiffness contribution of heavy-weight claddings on buildings and the role of cladding in altering dynamic properties and linear seismic response were investigated.

83-2152
Damage Analyses of Imperial County Services Building
R. Shepherd and A.W. Plunkett
Univ. of California, Irvine, CA 92717, ASCE J. Struc. Engrg., 109 (7), pp 1711-1726 (July 1983) 15 figs, 6 refs

Key Words: Buildings, Reinforced concrete, Concretes, Earthquake damage

The failure of the Imperial County Services Building in El Centro, California, during the Imperial Valley Earthquake on October 15, 1979, is examined. The event was exceptional insofar as a modern reinforced concrete building, designed to comply with a recent code, extensively instrumented and previously subjected to dynamic testing, was severely damaged. Available records of measured dynamic characteristics and traces of the motions induced by the earthquake in both the adjacent ground and the structure, enable critical analyses to be made of the failure modes.

FOUNDATIONS

83-2153
Dynamic Stiffness of Two Layers in Contact Subjected to Torsional Oscillations

H.H. Jabali
Ph.D. Thesis, Univ. of Miami, 57 pp (1982)
DA8313094

Key Words: Foundations, Layered materials, Seismic analysis, Torsional excitation, Interaction: soil-structure

Of important practical interest to engineers involved in seismic analysis is the response of a structure on a layered foundation. For such a study, the dynamic stiffness of the foundation must be investigated. The forced torsional vibration of an elastic stratum consisting of two layers in contact and of dissimilar material is considered.

HARBORS AND DAMS

83-2154
Nonstationary Random Vibrations of an Elastic Gravity Dam with an Arbitrary Shaped Cylindrical Reservoir (Instationäre Zufallsschwingungen einer elastischen Gewichtsmauer bei beliebig geformtem Becken)
F. Hollinger and F. Ziegler
Technische Univ. Wien, Vienna, Austria, Z. angew. Math. Mech., 63 (1), pp 49-54 (1983) 3 figs, 17 refs (In German)

Key Words: Dams, Seismic response, Earthquake response, Random excitation

A solution for earthquake excited vibrations of a linear elastic gravity dam (in plane strain) including hydrodynamic interaction with the two-dimensional, linear compressible, inviscid fluid body in an arbitrary shaped cylindrical reservoir is presented. The plane hydrodynamic problem is solved by means of a boundary integral equation method. The plane vibrations induced by nonstationary random excitation processes are given by time variant power spectral densities.

83-2155
On the Nonlinear Dynamic Response of Arch Dams to Earthquakes - I. Fluid-Structure Interaction: Added-Mass Computations for Incompressible Fluid. II. Joint Opening Nonlinear Mechanism: Interface Smeared Crack Model
J.S-H. Kuo
Ph.D. Thesis, Univ. of California, Berkeley, 202 pp (1982)
DA8312876

Key Words: Dams, Seismic response, Interaction: structure-fluid

Two topics are studied with regard to the analysis of nonlinear dynamic response of arch dams to earthquakes. Part I deals with the dam-reservoir effects considering incompressible fluid. The hydrodynamic effect represented by added-mass matrix is evaluated by two basically different procedures -- a generalized Westergaard formula and the Galerkin finite element method. Part II deals with the contraction joint opening behavior. An economical model called the Interface Smeared Crack Model is developed to simulate the joint opening nonlinear mechanism.

POWER PLANTS
(See Nos. 2203, 2277)

OFF-SHORE STRUCTURES

83-2156
Dynamic Ice-Structure Interaction During Continuous Crushing
M. Maattanen
Cold Regions Res. and Engrg. Lab., Hanover, NH, Rept. No. CRREL-83-5, 56 pp (Feb 1983)
AD-A126 349

Key Words: Interaction: ice-structure, Off-shore structures, Model testing, Experimental test data

This report presents the results of dynamic ice-structure interaction model tests conducted at the CRREL Ice Engineering Facility. A flexible, single-pile, bottom-founded offshore structure was simulated by a test pile with about a one-to-ten scale ratio. Six ice fields were frozen and 18 tests carried out. In all cases distinctive dynamic ice structure interaction vibrations appeared, from which abundant data were collected.

VEHICLE SYSTEMS

GROUND VEHICLES

(Also see Nos. 2177, 2182, 2346)

83-2157

Suspension Bounce Response of Canadian MAGLEV Vehicle under Guideway Excitations. Part 1: Deterministic Analysis

M. Kotb, T.S. Sankar, and M. Samaha

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 104-111 (Jan 1983) 9 figs, 9 refs

Key Words: Ground effect machines, Magnetic vehicle suspensions, Periodic excitation, Guideways, Time domain method, Frequency domain method

The dynamic bounce response of the Canadian designed high speed magnetically levitated vehicle is investigated when subjected to purely periodic excitations from the guideways. The equations of motion of the system are derived, on the basis of a realistic linear mathematical model, using d'Alembert's principle of force and moment analysis. Solutions for the system responses in the time and frequency domain are obtained using numerical techniques.

83-2158

Results of Analysis of 70 Ton Boxcar Vibration Tests

G. Kachadourian

MITRE Corporation, McLean, VA, Rept. No. MTR-82W00104, DOT/FRA/ORD-83/06, 68 pp (Mar 1983)

PB83-197723

Key Words: Freight cars, Box cars, Vibration tests

This is the second of three volumes covering tests performed on a 70 ton boxcar with Barber S-2-C trucks. The objective of the testing was to define the dynamic properties of the freight car for use in validating a mathematical model. The testing was conducted in two phases: static tests were performed on each truck to characterize its stiffness and damping properties; vibration tests were performed on the complete boxcar, loaded and empty, to determine resonant frequencies.

AIRCRAFT

(Also see Nos. 2246, 2278, 2351)

83-2159

Enhanced Manual Controllability Via Active Control of Aeroelastic Vehicles

D.K. Schmidt

School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. NASA-CR-170118, 58 pp (1983)

N83-20952

Key Words: Aircraft, Elasticity theory, Modal analysis, Active control

A modal analysis technique was developed for evaluating the effects of elastic modes on aircraft dynamic response, and the handling qualities implication of these effects.

83-2160

Real-Time Flutter Analysis of an Active Flutter-Suppression System on a Remotely Piloted Research Aircraft

G.B. Gilyard and J.W. Edwards

Hugh L. Dryden Flight Res. Ctr., NASA, Edwards, CA, Rept. No. NASA-TM-84901, 18 pp (Jan 1983)

N83-18710

Key Words: Aircraft, Flutter, Active-flutter control, Real time spectrum analyzers

Flight flutter-test results of the first aeroelastic research wing of NASA's drones for aerodynamic and structural testing program are presented. The flight-test operation and the implementation of the active flutter-suppression system are described as well as the software techniques used to obtain real-time damping estimates and the actual flutter testing procedure.

83-2161

Flight Equation of Motion: Computer Analysis. 1972 - April 1983 (Citations from the International Aerospace Abstracts Data Base)

NTIS, Springfield, VA, 254 pp (Apr 1983)

PB83-863100

Key Words: Aircraft, Spacecraft, Flutter, Dynamic structural analysis, Computer programs, Bibliographies

This bibliography contains 251 citations concerning mathematical procedures explaining the nature of objects in motion. The topics present a variety of examples and experiments and include spin performance of aircraft, airframe flutter and dynamic structural analysis, aircraft performance, accident analysis, flight simulation, missile and weapons data, and spacecraft performance. The solutions presented emphasize computer optimizations and techniques documenting both analog and digital modeling.

83-2162

Analysis of Unswept and Swept Wing Chordwise Pressure Data from an Oscillating NACA 0012 Airfoil Experiment. Volume 1. Technical Report

A.O. St. Hilaire and F.O. Carta
United Technologies Res. Ctr., East Hartford, CT, Rept. No. NASA-CR-3567, 101 pp (Mar 1983)
AD-A126 797

Key Words: Aircraft wings, Airfoils, Aerodynamic stability

The objective of this investigation was to study the unsteady chordwise force response on the airfoil surface and to examine its sensitivity to the various system parameters. The main body of this data analysis was carried out by analyzing the propagation speed of pressure disturbances along the chord and by studying the behavior of the unsteady part of the chordwise pressure distribution at various points of the airfoil pitching cycle.

83-2163

Aeroelastic Properties of Straight and Forward Swept Graphite/Epoxy Wings

B.J. Landsberger
Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/CI/NR-83-11T, 159 pp (Feb 1983)
AD-A127 014

Key Words: Aircraft wings, Cantilever plates, Aeroelasticity, Natural frequencies, Flutter

The aeroelastic deformation, divergence and flutter behavior of rectangular, graphite/epoxy, cantilevered plate type wings at zero sweep and thirty degrees of forward sweep is investigated for incompressible flow. Since the wings have varying amounts of bending stiffness, torsion stiffness and bending-torsion stiffness coupling, they each have unique aeroelastic properties. A five mode Rayleigh-Ritz formulation is used to calculate the equation of motion.

83-2164

Transonic Pressure Distributions on a Rectangular Supercritical Wing Oscillating in Pitch

R.H. Ricketts, M.C. Sandford, D.A. Seidel, and J.J. Watson
NASA Langley Res. Ctr., Hampton, VA, NASA-TM-84616, AIAA-PAPER-83-0923, 12 pp (Mar 1983) (Presented at 24th AIAA/ASME/ASCE/AHS Struct., Struct. Dyn. and Mater. Conf., Lake Tahoe, NV, May 2-4, 1983)
N83-20914

Key Words: Aircraft wings, Airfoils, Aerodynamic loads, Experimental test data

Steady and unsteady aerodynamic data were measured on a rectangular wing with a 12 percent thick supercritical airfoil. The wing was oscillated in pitch to generate the unsteady aerodynamic data. The purpose of the wind-tunnel test was to measure data for use in the development and assessment of transonic analytical codes. The effects on the wing pressure distributions of Mach number, mean angle of attack, and oscillation frequency and amplitude were measured.

83-2165

Computer Simulation of an Aircraft Seat and Occupant in a Crash Environment. Volume II. Program SOM-LA (Seat/Occupant Model - Light Aircraft) User Manual

D.H. Laananen, J.W. Coltman, and A.O. Bolukbasi
Simula, Inc., Tempe, AZ, Rept. No. TR-81415, DOT/FAA/CT-82/33-2, 234 pp (Mar 1983)
AD-A127 286

Key Words: Crash research (aircraft), Crashworthiness, Aircraft seats, Human response, Safety restraint systems, Computer programs

A mathematical model of an aircraft seat, occupant, and restraint system has been developed for use in analysis of light aircraft crashworthiness. Because of the significant role played by the seat in overall system crashworthiness, a finite element model of the seat structure is included. This volume of the final report presents instructions for preparing input data and operating the program, supported by detailed example. Sample material properties and modeling parameters are also included.

83-2166

YAH-63 Helicopter Crashworthiness Simulation and Analysis

V.L. Berry, J.D. Cronkhite, T.J. Haas, and G.S. Perry
Bell Helicopter Textron, Fort Worth, TX, Rept. No. USAAVRADCOM-TR-82-D-34, 259 pp (Feb 1983)
AD-A125 642

Key Words: Helicopters, Crashworthiness, Experimental test data

Under its ongoing crash research testing program, the Army conducted drop test T-41 using a YAH-63 prototype helicopter as a test article. The YAH-63 was residual hardware from the AAH competition of the mid 70's and incorporated many crashworthy features, including a high energy landing gear, crushable fuselage structure, stroking crew seats, high strength retention of large masses, and a crash-resistant fuel system.

83-2167

Calculation of the Longitudinal Stability Derivatives and Modes of Motion for Helicopter Aircraft

H.J. O'Neil
M.S. Thesis, Naval Postgraduate School, Monterey, CA, 114 pp (Oct 1982)
AD-A125 593

Key Words: Helicopters, Dynamic stability

An analysis of the longitudinal stability derivatives for helicopter aircraft is presented and intended to be used as a resource document for a helicopter stability and control course. Emphasis is given to the evolution of forces and moments on the helicopter, calculation of the stability derivatives at high advance ratios, derivation of the stability determinant and solution of the characteristic equation to yield the modes of motion of the helicopter.

83-2168

X-Wing Noise Data Acquisition Program

G.J. Healy
Lockheed Aircraft Corp., Burbank, CA, Rept. No. NASA-CR-166454, 90 pp (Feb 1983)
N83-18717

Key Words: Helicopters, Propeller blades, Noise measurement

The X-wing circulation controlled rotor system model was tested for hover performance. During these performance tests, noise data from 12 microphones was recorded on magnetic tape for subsequent data reduction. The rotor system was operated at 4 tip speeds. Following completion of the rotor and subsystem noise measurements, sound field calibration measurements were made of both the rotor bowl and the loudspeaker system used in the bowl calibration measurements.

83-2169

***Design of* Helicopter Rotor Blades for Optimum Dynamic Characteristics**

D.A. Peters, T. Ko, A.E. Korn, and M.P. Rossow
Dept. of Mech. Engrg., Washington Univ., St. Louis, MO, Rept. No. NASA-CR-169940, 81 pp (Feb 1983)
N83-18716

Key Words: Helicopters, Propeller blades, Optimum design

The possibilities and limitations of tailoring blade mass and stiffness distributions to give an optimum blade design in terms of weight, inertia, and dynamic characteristics are discussed. The extent that changes in mass of stiffness distribution can be used to place rotor frequencies at desired locations is determined. Theoretical limits to the amount of frequency shift are established. Realistic constraints on blade properties based on weight, mass, moment of inertia, size, strength, and stability are formulated. The extent that the hub loads can be minimized by proper choice of EI distribution, and the minimum hub loads which can be approximated by a design for a given set of natural frequencies are determined. Aerodynamic couplings that might affect the optimum blade design, and the relative effectiveness of mass and stiffness distribution on the optimization procedure are investigated.

MISSILES AND SPACECRAFT

(Also see No. 2161)

83-2170

Dynamics of a Deploying Orbiting Beam-Type Appendage Undergoing Vibrations

K.W. Lips and V.J. Modi
Dept. of Mech. Engrg., The Univ. of British Columbia, Vancouver, B.C. Canada V6T IW5, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 33-39 (Jan 1983) 7 figs, 11 refs

Key Words: Spacecraft antennas, Vibration analysis

Vibration characteristics associated with a deploying spacecraft appendage in an arbitrary orbit are investigated numerically. A general formulation of the problem is presented which accounts for the shifting center of mass, appendage offset, arbitrary variation of flexural rigidity along the appendage length, deployment acceleration, satellite librations, etc.

83-2171
Equivalent Angle-of-Attack Method for Estimating Nonlinear Aerodynamics of Missile Fins
M.J. Hemsch and J.N. Nielsen
Nielsen Engrg. & Res., Inc., Mountain View, CA, J. Spacecraft Rockets, 20 (4), pp 356-362 (July/Aug 1983) 9 figs, 1 table, 19 refs

Key Words: Missile components, Aerodynamic stability

A method has been developed for estimating the nonlinear aerodynamic characteristics of missile wing and control surfaces. The method is based on the assumption that if a fin on a body has the same normal-force coefficient as a wing alone composed of two of the same fins joined together at their root chords, then the other force and moment coefficients of the fin and the wing alone are the same, including the nonlinearities. The method can be used for deflected fins at arbitrary bank angles and at high angles of attack. A full derivation of the method is given, its accuracy is demonstrated, and its use in extending missile data bases is shown.

BIOLOGICAL SYSTEMS

HUMAN

83-2172
Physical Parameters in the Evaluation of the Annoyance of Industrial Noises (Physikalische Parameter bei der Bewertung der Lästigkeit von Industriegeräuschen)
W. Brennecke and H. Remmers
Fachbereich Physik an der Universität Oldenburg, Acustica, 52 (5), pp 279-280, 281-289 (Apr 1983) 9 figs, 3 tables, 28 refs
(In German)

Key Words: Industrial facilities, Noise generation, Human response

Twenty-five representative industrial noises are presented to 80 subjects for the evaluation of annoyance by pair-comparison. The evaluation of the subjective estimation is made by the process of the principle components analysis. Relevant acoustic parameters, whose measuring methods are presented and discussed, are taken for correlation with these results.

MECHANICAL COMPONENTS

ABSORBERS AND ISOLATORS
(Also see Nos. 2181, 2264, 2283)

83-2173
Optimal Design of Linear and Nonlinear Vibration Absorbers for Damped Systems
A. Soom and M.-S. Lee
Dept. of Mech. and Aerospace Engrg., State Univ. of New York at Buffalo, Amherst, NY 14260, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 112-119 (Jan 1983) 18 figs, 11 refs

Key Words: Dynamic vibration absorption (equipment), Tuning, Damping, Optimum design

Nonlinear programming techniques are applied to obtain optimal tuning and damping parameters for dynamic absorbers. The optimization is carried out for damped as well as undamped primary systems. It is found that optimal tuning parameters, obtained with the goal of minimizing the main mass maximum displacement, undergo small changes as damping is introduced into the main system.

83-2174
Method of Actuator Placement for Vibration Control of Large Space Structures
R.E. Ort

Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/CI/NR-83-1-T, 90 pp (Feb 1983) AD-A126 940

Key Words: Vibration control, Active vibration control

This thesis presents several computationally simple techniques for choosing actuator placement on large space structures. Actuator and performance information can be represented as vectors (node shapes) in modal coordinates. The placement problem is stated as choosing a set of actuator node shapes to match the performance node shape. One method sequentially selects a set of actuator node shapes such that the norm of the component orthogonal to the already selected set is large. Another method sequentially selects actuator node shapes such that a large projection is obtained along the least squares residual vector resulting from the fit of the previously selected set to the performance node shape. These techniques are applied to a 100 meter cantilever beam.

83-2175

Fail-Safe Vibration Control Using Active Force Generators

R.R. Guntur and S. Sankar

Dept. of Mech. Engrg., Concordia Univ., Montreal, Quebec, Canada, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 361-368 (July 1983) 15 figs, 1 table, 11 refs

Key Words: Active vibration control, Suspension systems (vehicles)

Using the concept of force generators, various active vibration configurations have been examined for their performance potential. It is shown that an active vibration control system offers a great deal of flexibility in that by a proper choice of active components its transmissibility characteristics can be altered to suit the requirements. It is also shown how the full potential of active systems can be achieved even when there are passive components.

83-2176

Study of Ride Comfort Using a Nonlinear Mathematical Model of a Vehicle Suspension

A. Jolly

Direction des Recherches et des Developpements de la Regie Nationale des Usines Renault, Rueil-Malmaison, France, Intl. J. Vehicle Des., 4 (3), pp 233-244 (May 1983) 11 figs, 7 refs

Key Words: Suspension systems (vehicles), Mathematical models, Human response

An approach for the design of a new car suspension using a nonlinear mathematical model is described. A brief description of the linear de Carbon model and its properties is recalled; effects and importance of some nonlinear parameters are discussed; a model including these parameters is introduced and it is shown that this nonlinear model still approximately verifies one property of the de Carbon model. Using this important characteristic, a procedure for the design of a new suspension using a nonlinear model is presented.

83-2177

Computer-Aided Analysis and Experimental Verification of a Motorcycle Suspension

M. van Vliet and S. Sankar

Concordia Univ., Montreal, Quebec, Canada H3G 1M8, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 120-131 (Jan 1983) 20 figs, 3 tables, 17 refs

Key Words: Suspension systems (vehicles), Motorcycles, Computer-aided techniques

A computer-aided analysis and experimental verification of a motorcycle suspension are presented. A mathematical model describing the flow characteristics in a front fork and a rear shock absorber was independently developed for both compression and extension strokes. The model includes both laminar and turbulent flow conditions and the spring effect due to entrapped air in front fork and gas charged chamber in the case of rear shock absorber. A sinusoidal displacement was considered as the input excitation for the model.

83-2178

Determination of Dynamic Properties of Elastomers over Broad Frequency Range

G.M. Smith, R.L. Bierman, and S.J. Zitek

Univ. of Nebraska, Lincoln, NE 6588-0347, Exptl. Mech., 23 (2), pp 158-163 (June 1983) 10 figs, 6 refs

Key Words: Elastomers, Dynamic tests, Dynamic properties, High frequencies

Support excitation of a small spring-mass system, consisting of a mass m and two thin wafers in shear, is used as a simple and reliable method to determine the dynamic properties

(storage-modulus and complex-modulus loss factor) of elastomeric materials over a fairly broad frequency range. No special equipment or instrumentation is required since ordinary vibration equipment is used. Microminiature accelerometers are used to monitor the support and mass accelerations which eliminates the measurement of small forces and displacements.

83-2179

Energy Absorption of Composite Materials

G.L. Farley

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-84638, 9 pp (Mar 1983) (Presented at Natl. Specialists' Meeting: Composite Structures, Mar 1983; Sponsored by American Helicopter Soc.) N83-19816

Key Words: Energy absorption, Composite materials, Compressive strength

Results of a study on the energy absorption characteristics of selected composite material systems are presented and the results compared with aluminum.

83-2180

Review of Data on Rubber Mountings

Chartered Mech. Engr., 30 (6), pp 28-31 (June 1983) 13 figs, 9 refs

Key Words: Mountings, Elastomers, Energy absorption

The material properties required for various applications of rubb mountings are presented.

SPRINGS

83-2181

Glass Fibre Reinforced Epoxy Leaf Spring Design

W.G. Gottenberg and K.H. Lo

Shell Development Co., Westhollow Research Ctr., 3333 Highway 6 South, Houston, TX 77001, Intl. J. Vehicle Des., 4 (3), pp 312-322 (May 1983) 4 figs, 2 tables, 2 refs

Key Words: Springs, Leaf springs, Energy absorption

Composite leaf springs constructed of unidirectional glass fibers in an epoxy resin matrix are being recognized as a viable replacement for steel springs in truck and automotive suspension applications. This paper reviews the function of a spring as an energy storage device. It examines in detail the influence on that function of the material of construction (unidirectional glass fibers in epoxy versus steel) and of spring geometry. The design latitudes afforded by the variable thickness/width options are illustrated. Finally, the significance of shear stress components in planes containing the fibers is examined, particularly in its relation to the selection of the thermoset resin matrix.

TIRES AND WHEELS

83-2182

Eulerian Dynamics of a Bicone

M. Decuyper

Universite Catholique de Louvain, Louvain-la-Neuve, Belgium, Intl. J. Vehicle Des., 4 (4), pp 413-429 (July 1983) 4 figs, 2 tables, 4 refs

Key Words: Wheelsets, Railway wheels, Conical bodies, Euler equation, Equations of motion, Railroad cars

The purpose of this paper is to resume the problem of wheelset dynamics at a fundamental level by deriving the Eulerian equations of motion of an idealized model of wheelset on an idealized track. The translation and rotation equations are derived for a bicone (pair of conical wheels) of any conicity on a straight sharp-edged track. The kinematical constraints are deduced from nonlinear analytical principles which are then linearized.

83-2183

On the Lateral Stability of a Flexible Truck

A.M. Whitman

Tel-Aviv Univ., Tel-Aviv, Israel, J. Dynam. Syst., Meas. Control, Trans. ASME, 105 (5), pp 120-125 (June 1983) 7 figs, 7 refs

Key Words: Wheelsets, Railway wheels, Railroad cars, Stability, Lateral response

Analytic formulae for the critical speed and frequency of an interconnected pair of wheelsets based on an asymptotic expansion in a truck geometric parameter are derived. No restriction is placed on the values of either the shear or bending stiffness; the entire structure of the stability surface is obtained. Expressions are obtained for the local and global extrema and their locations.

BLADES

(Also see No. 2224)

83-2184

An Actuator Disc Analysis of Unsteady Supersonic Cascade Flow

D.S. Whitehead and M.R.D. Davies
Whittle Lab., Cambridge Univ. Engrg. Dept., Cambridge, UK, J. Sound Vib., 88 (2), pp 197-206 (May 22, 1983) 4 figs, 10 refs

Key Words: Blades, Cascades, Disks (shapes), Plates, Fluid-induced excitation

A simple analytical result is derived for the aerodynamic forces and moments acting on a cascade of unloaded flat plates vibrating in a supersonic flow. The principal assumptions are that the axial velocity is subsonic, that the blades are sufficiently closely spaced so that a Mach wave cannot propagate upstream through the cascade, and that the frequency parameter and inter-blade phase angle are both small. The unique incidence condition is used.

83-2185

Turbomachine Blade Vibration

J.S. Rao
Indian Inst. of Tech., New Delhi-110016, India, Shock Vib. Dig., 15 (5), pp 3-9 (May 1983) 90 refs

Key Words: Blades, Turbomachinery blades, Free vibration, Reviews

This article reviews the literature that has appeared since 1979 on free vibrations and excitation forces of blades and blade response.

83-2186

The Vibration and Stability Analysis of Axially Moving Materials: A Special Study on Band Saw Systems

W.-Z. Wu
Ph.D. Thesis, Univ. of California, Berkeley, 112 pp (1982)
DA8313027

Key Words: Saws, Blades, Natural frequencies, Mode shapes, Flexural vibration, Torsional vibration

The variation of natural frequencies and mode shapes of a cutting blade from dynamic vibration to static buckling are studied. Bending-torsional coupled transverse vibrations in a linear undamped axially moving thin beam model are investigated. The study also develops an accurate, comprehensive, fast and inexpensive analytical method for efficient analyses of the natural frequencies and mode shapes of the cutting blade. Parametric resonances caused by a periodic edge load in the plane of a moving band and normal to the longitudinal axis are also investigated. The relationship, to cause a parametric instability and induce a large amplitude transverse vibration, among the moving velocity, the tension, the system compliance coefficient, and the periodic load amplitude as well as variation frequency is established in this study.

BEARINGS

(Also see No. 2226)

83-2187

Eccentric Operation of Conical Hydrostatic Thrust Bearings

J.J. Prabhu and N. Ganesan
Machine Dynamics Lab., Dept. of Applied Mechanics, Indian Inst. of Tech., Madras 600036, India, Wear, 87, pp 273-285 (1983) 19 figs, 11 refs

Key Words: Bearings, Eccentricity

A theoretical study of the behavior of capillary-compensated annular recess conical hydrostatic thrust bearings under conditions of eccentricity and rotation is reported. The influence of aspect ratios, cone angles and resistance ratios on the static and dynamic characteristics is discussed.

83-2188

Hydrodynamic Instability of Self-Acting Journal Bearings of Finite Length in the Turbulent Regime

V. Kumar
Regional Engrg. College, Kurukshetra Haryana,

132119, India, Wear, 88 (2), pp 133-143 (July 1, 1983) 3 figs, 11 refs

Key Words: Bearings, Journal bearings, Dynamic stability

An analysis for the determination of the conditions of dynamic stability of hydrodynamically lubricated plain circular bearings of finite length with turbulent flow is presented. The conditions for both static and dynamic stability are calculated from the response to a small random disturbance. The dynamic stability is investigated with the Routh-Hurwitz criterion using the perturbation (or linearization) technique. The results are fully analytical and are in the closed form.

83-2189

Rolling Bearing Noise -- Cause and Cure

F.P. Wardle and S.Y. Poon

RHP Bearing Res. Ctr., Chartered Mech. Engr., 30 (7/8), pp 36-40 (Aug 1983) 14 figs, 3 refs

Key Words: Bearings, Rolling contact bearings, Noise generation, Noise reduction

Rolling bearings are quiet running components and only become noticeable as sources of noise in a limited range of machines. These machines usually share a number of common features: they are used in quiet environments, have few other sources of noise and run at speeds of more than 1000 rev/min.

83-2190

Some Dynamic Effects in High-Speed Solid-Lubricated Ball Bearings

P.K. Gupta

Mechanical Technology Inc., Latham, NY 12110, ASLE, Trans., 26 (3), pp 393-400 (July 1983) 8 figs, 1 table, 14 refs

Key Words: Bearings, Ball bearings, Computer programs

Dynamic performance simulations of a high-load, high-speed ball bearing for turbine-engine applications are considered using the available dynamics of rolling element bearings computer program. It is shown that the key element in the bearing design is the traction behavior at the ballrace interface for the prescribed materials. With a given traction model, the geometry of the bearing may be designed to ensure acceptable ball/cage collision forces and to ensure the general stability of the cage.

83-2191

Analysis of Misaligned Journal Bearings with Axial and Spiral Feeding

M.O.A. Mokhtar, M.A. Abdel Rahman, and Z.S. Safar

Mechanical Design Dept., Cairo Univ., Cairo, Egypt, Wear, 85 (3), pp 331-337 (Mar 15, 1983) 7 figs, 4 refs

Key Words: Bearings, Journal bearings, Alignment

An analysis of misaligned journal bearings with both axial and spiral feeding is presented. The misalignment varies in magnitude and in direction with respect to the bearing boundaries. Results for a stationary journal centre and L/D = 1 demonstrate that misalignment in line with the axial plane containing the load vector is more advantageous and that bearings with axial feeding produce higher loads and smaller values of the coefficient of friction than bearings with spiral feeding.

83-2192

Design of an Offset Hydrostatic Thrust Bearing under Dynamic Loading Conditions

Z.S. Safar

Dept. of Mech. Engrg., Cairo Univ., Cairo, Egypt, Wear, 84 (1), pp 87-96 (Jan 1, 1983) 9 figs, 9 refs

Key Words: Bearings, Thrust bearings, Saws, Vibration effects

An offset hydrostatic thrust bearing is analyzed to determine the effect of vibration of the rotating plate on performance characteristics. The flow developed is asymmetric because the surface rotation axis is offset from the bearing axis. The governing Reynolds equation is solved using semi-analytical methods. The average load capacity, frictional force and lubricant flow rate are strong functions of the bearing offset L, bearing number λ, film thickness profile H, film thickness variation ϵ and the ratio between the frequency of vibration of the rotating plate and the angular speed of rotation.

GEARS

83-2193

Calculation of Tooth Forces, Pressures and Stresses in Spur and Bevel Gears (Berechnung der Zahnkräfte, Pressungen und Spannungen von Stirn- und Kegelradgetrieben)

B. Neupert

Fortschritt-Berichte VDI-Zt., Reihe 1, No. 104 (1983), 162 pp, 85 figs. Summarized in VDI-Z, 125 (10), pp 360-361 (May 1983). Avail: VDI-Berlag GmbH, Postfach 1139, 4000 Dusseldorf 1, Germany. Price 54.00 DM
(In German)

Key Words: Gears, Spur gears, Bevel gears, Gear teeth, Computer programs

A general form algorithm is presented which is particularly suitable for the calculation of complex relationships between tooth forces, deformation, and stresses in helical gears during engagement. The calculations are in the form of consecutively run digital computer programs with 30,000 Fortran commands. Because of its general form the method can be used for other types of gears, as well as for failure analysis of gears. In addition, the algorithms developed can also be used in other contact problems, such as for the determination of load distribution in rolling element bearings, and in guidance systems for machine tools as well as for the optimum sizing of ball bearings.

83-2194
Dynamic Tooth Loads and Stressing for High Contact Ratio Spur Gears
R.W. Cornell and W.W. Westervelt
Hamilton Standard Div., United Technologies Corp., Windsor Locks, CT, 12 pp (Jan 1983) from Advanced Power Transmission Technology, Proc. of Symp. held at NASA Lewis Res. Ctr., Cleveland, OH, June 9-11, 1981
AD-A126 186
AD-P000 727

Key Words: Gears, Spur gears, Gear teeth, Computer programs

An analysis and computer program has been developed for calculating the dynamic gear tooth loading and root stressing for HCRG as well as LCRG. The analysis includes the effects of the variable tooth stiffness during the mesh, tooth-profile modification, and gear errors. The calculation of the tooth root stressing caused by the dynamic gear loads is based on a modified Heywood gear tooth stress analysis, which appears more universally applicable to both LCRG and HCRG.

83-2195
Method for Static and Dynamic Load Analysis of Standard and Modified Spur Gears
R. Kasuba
Cleveland State Univ., OH, 17 pp (Jan 1983) from: Advanced Power Transmission Technology, Proc. of Symp. held at NASA Lewis Res. Ctr., Cleveland, OH, June 9-11, 1981
AD-A126 186
AD-P000 722

Key Words: Gears, Spur gears, High-contact ratio gears

Many advanced technology applications have a general requirement that the power to transmission weight be increased. The ability to accurately calculate the dynamic loads becomes essential for advanced transmission design. This paper discusses the mesh stiffness and dynamic load characteristics for several cases of normal contact ratio and high contact ratio gearing.

83-2196
Computer Solution for the Dynamic Load, Lubricant Film Thickness, and Surface Temperatures in Spiral-Bevel Gears
H.C. Chao, M. Baxter, and H.S. Cheng
Garrett Turbine Engine Co., Phoenix, AZ, 19 pp (Jan 1983) from: Advanced Power Transmission Technology, Proc. of Symp. held at NASA Lewis Res. Ctr., Cleveland, OH, June 9-11
AD-A126 186
AD-P000 719

Key Words: Gears, Bevel gears, Computer programs

A computer solution to the dynamic load in a pair of spiral-bevel gearsets was developed by solving the equations of motion for the pinion and gear shaft. An existing finite-element code was used to calculate the combined stiffness of the contacting pinion and gear teeth as a function of contacting position in the zone of action. In addition to the dynamic load analysis, a computer solution was also developed to predict the bulk surface temperature, the flash temperature, and the film thickness along the contact path.

FASTENERS

83-2197
Seismic Moment Connections for Moment-Resisting Steel Frames
E.P. Popov

Earthquake Engrg. Res. Ctr., Univ. of California, Berkeley, CA, Rept. No. UCB/EERC-83/02, NSF/CEE-83009, 65 pp (Jan 1983)
PB83-195412

Key Words: Joints (junctions), Framed structures, Steel, Seismic response

This report provides an overview of the state of the art for the design of steel moment connections for regions of high seismic risk. The need for designing such connections to be ductile with the capacity to sustain full load reversals is indicated. A major section of the report is devoted to presentation of experimental results to illustrate the observed behavior of beam-to-column connections and column panel zones under severe cyclic loadings simulating extreme seismic conditions.

83-2198

System Identification of Structures with Joint Rotation

J.S. Dimsdale
Ph.D. Thesis, Univ. of California, Berkeley, 144 pp (1982)
DA8312798

Key Words: Joints (junctions), Framed structures, Seismic excitation, System identification techniques

The goal of this research is to investigate the role of joint behavior in the identification of frame models from dynamic response data caused by seismic forcing functions. Including joint rotation and deformation in the mathematical model for even simple structures significantly affects the distribution of stiffness, and the accuracy with which response can be predicted. An optical method has been devised for accurately measuring joint rotation of a structure during earthquake excitation. A number of different mathematical models of these structures are evaluated using system identification.

83-2199

Experimental and Analytical Study of Internal Beam to Column Connections Subjected to Reversed Cyclic Loading

A.J. Durrani and J.K. Wight
Dept. of Civil Engrg., Univ. of Michigan, Ann Arbor, MI, Rept. No. UMEE-82R3, NSF/CEE-82097, 298 pp (July 1982)
PB83-188359

Key Words: Joints (junctions), Beams, Columns, Seismic response

Six full-sized interior beam-to-column subassemblages were tested under quasi-static loading which was intended to simulate earthquake input. Three variables were investigated: percentage of transverse hoop reinforcement in the joint; joint shear stress level; and presence of transverse beams and slab on half of the specimens.

83-2200

The Damping of Structural Vibration by Controlled Interfacial Slip in Joints

C.F. Beards
Dept. of Mech. Engrg., Imperial College of Science and Technology, London SW7, UK, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 369-373 (July 1983) 4 figs, 41 refs

Key Words: Joints (junctions), Vibration damping, Beams, Plates, Framed structures, Structural members

The most significant source of damping inherent in a structure is that damping which occurs in the structural joints due to interfacial slip. Particular emphasis should be put on controlling and increasing the damping which occurs in these joints if the dynamic response, stress, and noise of a structure are to be reduced. It is shown that an optimum joint clamping force exists for maximum energy dissipation due to slip, and that the resonance frequencies of structures can be controlled to some extent by adjusting the clamping and, hence, the slip, in joints. The application of joint damping to beam-like structures, plates, and frameworks is considered, and its effect on the vibration of these structures discussed.

83-2201

Behavior of External Reinforced Concrete Beam to Column Connections Subjected to Earthquake Type Loading

M.R. Ehsani and J.K. Wight
Dept. of Civil Engrg., Univ. of Michigan, Ann Arbor, MI, Rept. No. UMEE-82R5, NSF/82099, 267 pp (July 1982)
PB83-188342

Key Words: Joints (junctions), Beams, Reinforced concrete, Columns, Seismic excitation, Earthquakes, Dynamic tests

Twelve full-size exterior beam-to-column subassemblies were constructed and tested. The primary variables studied

were: ratio of the sum of the flexural strengths of the columns to that of the beam; amount of transverse reinforcement placed within the joint; shear stress in the joint; and inclusion of transverse beams and slab for half of the specimens.

83-2202
The Fatigue of Weldments Subjected to Complex Loadings
New-Jin Ho
Ph.D. Thesis, Univ. of Illinois at Urbana-Champaign, 151 pp (1982)
DA8309957

Key Words: Joints (junctions), Welded joints, Fatigue life

Cruciform and double-strap lap weldments were fatigue tested under constant amplitude axial load and SAE bracket spectrum load conditions. The fatigue test results were compared with predictions made using an initiation-propagation model, and good agreement between experiment and theory was observed.

VALVES

83-2203
Response of Two Nuclear Power Plant Valves to Dynamic Excitation
S.F. Masri, S.J. Stott, and D.D. Reiff
Univ. of Southern California, Los Angeles, CA 90007, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 40-50 (Jan 1983) 29 figs, 5 refs

Key Words: Valves, Nuclear power plants, Nuclear reactor components, Shock excitation

To formulate more suitable testing criteria for safety-related equipment in nuclear power plants, new investigations of equipment behavior under dynamic loading are required. Currently used guidelines and their applicability are summarized and several major problems to be solved by new investigations are described. Experimental and analytical studies conducted on two typical valves exemplify the type of investigation required.

SEALS

83-2204
Dynamic Analysis of a Hydrodynamic Seal with Helical Grooves
S.K. Dhagat, R. Sinhasan, and D.V. Singh
Mech. Engrg. Dept., Govt. Engrg. College, Jabalpur 482011, India, Wear, 87 (2), pp 133-139 (May 16, 1983) 9 figs, 8 refs

Key Words: Seals, Stiffness coefficients, Damping coefficients

A ring-type hydrodynamic seal with two lands, one with helical grooves and the other with a wedge, separated by a circumferential oil supply groove was studied. The dynamic performance characteristics in terms of the stiffness and damping coefficients, critical mass and critical inertia were obtained for lateral and skew motions. For the general motion of the seal, stability studies were made by obtaining the roots of the characteristic equation.

STRUCTURAL COMPONENTS

CABLES
(Also see No. 2148)

83-2205
An Analysis of Elevator Rope Vibration in Tall Buildings
R.E. Blodgett and A.K. Majumdar
Merck and Co., Inc., Rahway, NJ, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 5-10 (Jan 1983) 8 figs, 2 tables, 1 ref

Key Words: Cables, Elevators, Multistory buildings, Vibration damping, Damping

The problem of elevator compensation rope vibration in tall buildings is addressed. An analysis is made of the vibrations of a hanging rope, whose weight per unit length is not negligible, excited by an oscillation at the upper end and having a weight suspended from the lower end. The effect of introducing a damper at the upper end in order to limit the vibration is also examined.

BARS AND RODS

83-2206

A New Higher Order Dynamic Theory for Thermoelastic Bars. I. General Theory

Y. Mengi and N. Akkas
Dept. of Civil Engrg., Cukurova Univ., Adana, Turkey, J. Acoust. Soc. Amer., 73 (6), pp 1918-1922 (June 1983) 1 fig, 8 refs

Key Words: Bars, Approximation methods, Vibration response, High frequency response

A dynamic approximate theory capable of predicting high-frequency behavior of cylindrical thermoelastic bars is developed. The cross section of the bar has an arbitrary shape and contains an arbitrary number of holes. The approximate theory is valid for all of the deformation modes -- flexural, longitudinal, torsional, etc. The use of the new method eliminates any inconsistency which may occur between lateral boundary conditions and the distributions of displacements or temperature assumed over the cross section of the bar.

83-2207

A New Higher Order Dynamic Theory for Thermoelastic Bars. II: Application to Thermoelastic Circular and Rectangular Bars

N. Akkas and Y. Mengi
Dept. of Civil Engrg., Middle East Technical Univ., Ankara, Turkey, J. Acoust. Soc. Amer., 73 (6), pp 1923-1931 (June 1983) 9 figs, 1 table, 4 refs

Key Words: Bars, Approximation methods, Vibration response, High frequency response

To illustrate the power of the theory proposed in Part I for the dynamic behavior of thermoelastic bars, the theory is applied to bars with circular and rectangular cross sections. The general equations of the approximate theory governing all of the deformation modes (longitudinal, flexural, torsional, etc.) of circular and rectangular bars, and accommodating the thermal effects are presented.

BEAMS

83-2208

The Effect of Shear Deformation and Rotatory Inertia on the Vibration Frequency of Uniformly Coated Single Field Beams (Einfluss von Schubelastizität und Drehträgheit auf die Biegeeigenfrequenz gleichförmig massebelegter Einfeldbalken)

R. Cuntze and J. Eder
Abteilung Strukturauslegung und Berechnung des M.A.N.-Bereichs Neue Technologie, München, Fed. Rep. Germany, Konstruktion, 35 (5), pp 183-186 (May 1983) 8 figs, 1 table, 7 refs
(In German)

Key Words: Beams, Layered materials, Timoshenko theory, Vibration effects

Graphs, based on the differential equations of Timoshenko beam theory, are presented for the determination of the effects of shear deformation and rotatory inertia of the cross section for five technically significant beam boundary conditions. The appropriate effect can be determined from their graphs using the curves of normalized correction coefficient K_{SD}. Theoretical predictions and calculation results are presented.

83-2209

Forced Vibration of Timoshenko Beams Made of Multimodular Materials

F. Gordaninejad and C.W. Bert
School of Aerospace, Mechanical and Nuclear Engrg., Univ. of Oklahoma, Norman, OK 73109, Rept. No. OU-AMNE-83-2, 31 pp (June 1983)

Key Words: Beams, Rectangular beams, Timoshenko theory, Transfer matrix method, Forced vibration

This paper presents a transfer-matrix analysis for determining the sinusoidal vibration response of thick, rectangular-cross-section beams made of multimodular materials; i.e., materials which have different elastic behavior in tension and compression, with nonlinear stress-strain curves approximated as piecewise linear. A closed-form solution is presented for the special case in which the neutral-surface location is uniform along the length of the beam. Comparisons are made among multimodular, bimodular (two line segments), and unimodular models. Numerical results for axial displacement, transverse deflection, bending slope, bending moment, transverse shear and axial forces, and the location of the neutral surface are presented for the multimodular model.

83-2210

Optimal Design of Beams under Flexural Vibration

M.H.S. Elwany and A.D.S. Barr

Dept. of Mathematical and Physical Sciences, Alexandria Univ., Alexandria, Egypt, J. Sound Vib., 88 (2), pp 175-195 (May 22, 1983) 9 figs, 10 tables, 8 refs

Key Words: Beams, Cantilever beams, Flexural vibration, Minimum weight design

The minimum weight design of a cantilever beam in flexural vibration is considered. The aim is the maximation of a given natural bending frequency (usually the first) for a given beam weight or equivalently the minimization of beam weight for a specified value of a natural frequency.

83-2211
Seismic Reliability of Damaged Concrete Beams

M. Shinozuka and R.Y. Tan
Columbia Univ., New York, NY 10027, ASCE J. Struc. Engrg., 109 (7), pp 1617-1634 (July 1983) 10 figs, 6 tables, 19 refs

Key Words: Beams, Earthquake damage, Seismic response, Probability theory

A method is developed to estimate the reliability of a seismically damaged structure that will be subjected to future earthquakes. Damage states are defined, and conditional as well as initial damage probability matrices are introduced in such a manner that the definition of the damage is consistent with the kind of accuracy achieved when the extent of the structural damage is estimated through field inspections.

CYLINDERS

(Also see Nos. 2226, 2229)

83-2212
Analysis of Vibration by Component Mode Synthesis Method (Part 3. Application to Cylinder Block of 4 Cylinders)

M. Ookuma and A. Nagamatsu
Doctor Course of Tokyo Inst. of Tech., Bull. JSME, 26 (215), pp 812-817 (May 1983) 15 figs, 11 refs

Key Words: Cylinders, Component mode synthesis, Vibration analysis

A cylinder block of 4 cylinders is analyzed by the component mode synthesis method, a general method of analysis of the vibration of a complex mechanical structure using the natural modes of the components. The natural modes of all components are synthesized to form the generalized system coordinates.

83-2213
Instability Mechanisms and Stability Criteria of a Group of Circular Cylinders Subjected to Cross-Flow. Part 1: Theory

S.S. Chen
Argonne Natl. Lab., Argonne, IL 60439, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 51-58 (Jan 1983) 1 fig, 19 refs

Key Words: Cylinders, Tube arrays, Fluid-induced excitation, Heat exchangers

A mathematical model is presented for a group of circular cylinders subject to cross-flow. It is found that there are two basic dynamic instability mechanisms: instability controlled by fluid damping and instability controlled by fluid-elastic force. Approximate closed form solutions of the critical flow velocity for the two mechanisms are obtained based on constrained-mode analyses.

83-2214
Fluidelastic Instability of an Infinite Double Row of Circular Cylinders Subject to a Uniform Cross-Flow

S.J. Price and M.P. Paidoussis
Dept. of Mech. Engrg., McGill Univ., Montreal, Quebec, H3A 2K6, Canada, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 59-66 (Jan 1983) 6 figs, 21 refs

Key Words: Cylinders, Tube arrays, Heat exchangers, Fluid-induced excitation

This paper represents the first stage of a fundamental investigation of the vibration phenomena induced in heat exchanger bundles subject to a cross-flow. Using aerodynamic force coefficient data, obtained experimentally from a static wind tunnel model, a linearized quasi-static analysis is employed to analyze the stability of an infinite double row of circular cylinders in uniform cross-flow. From the analysis it is shown that the instability is a result of the negative fluid damping forces, resulting from the complex flow pattern in the row.

FRAMES AND ARCHES

(Also see No. 2197)

83-2215

Bimodal Optimization of Vibrating Shallow Arches

N. Olhoff and R.H. Plaut
Dept. of Solid Mechanics, The Technical Univ. of Denmark, Lyngby, Denmark, Intl. J. Solids Struc., 19 (6), pp 553-570 (1983) 14 figs, 13 refs

Key Words: Arches, Natural frequencies, Optimization

A bimodal formulation is developed for the problem of maximizing the fundamental vibration frequency of shallow, elastic arches of given span, volume, length, material, and boundary conditions. Arches with different cross-sectional types are considered, and two simultaneous design variables are used; namely, the cross-sectional area and arch centerline functions. Results are also presented for arches with circular centerlines.

PLATES

(Also see No. 2163)

83-2216

On the Three Dimensional Analysis of Thick Laminated Plates

K.K. Teh, K.C. Brown, and R. Jones
Univ. of Melbourne, Parkville, Victoria 3052, Australia, J. Sound Vib., 88 (2), pp 213-224 (May 22, 1983) 2 figs, 8 tables, 26 refs

Key Words: Plates, Layered materials, Finite element technique, Natural frequencies

Several finite element models and finite prism models based on the elasticity theory formulation are compared. The basis of comparison is the accuracy in predicting natural frequencies of simply supported plates, and the suitability to model delamination of composite laminates. The emphasis of this work is on the finite prism method.

83-2217

The Use of Affine Transformations in the Analysis of Stability and Vibrations of Orthotropic Plates

G.A. Oyibo
Ph.D. Thesis, Rensselaer Polytechnic Inst., 218 pp (1981)
DA8311652

Key Words: Plates, Orthotropism, Stability, Vibration analysis

Transformations to solve the stability and vibrations problems of specially orthotropic plates are proposed. The affine transformations define the similarity rules for these plates, thereby reducing the numerous parameters (elastic constants) in the orthotropic literature to two. These affinely transformed parameters are the Generalized Poisson's Ratio and the Generalized Rigidity Ratio. With the help of these similarity rules, problems of a generic, rather than a specific, specially orthotropic plate can be solved at one time.

83-2218

Nonlinear Response Arising from Non Self-Similar Crack Growth in Finite Thickness Plates

G.C. Sih and C. Chen
Inst. of Fracture and Solid Mechanics, Lehigh Univ., Bethlehem, PA, Rept. No. ALO-1016, 45 pp (July 1982)
DE83005946

Key Words: Plates, Crack propagation, Finite element technique

Described in this report is a three-dimensional finite element procedure for finding the stresses in a finite thickness plate with a through crack. The Mode I loading is increased incrementally such that crack growth occurs in segments.

83-2219

Free Vibration of Circular-Segment-Shaped Membranes and Plates of Rectangular Orthotropy

T. Irie, G. Yamada, and Y. Kobayashi
Dept. of Mech. Engrg., Faculty of Engrg., Hokkaido Univ., Kita-13, Nishi-8, Kita-ku-Sapporo 060 Japan, J. Acoust. Soc. Amer., 73 (6), pp 2034-2040 (June 1983) 9 figs, 1 table, 15 refs

Key Words: Plates, Rectangular plates, Membranes (structural members), Harmonic excitation, Natural frequencies, Mode shapes

An analysis is presented for the free vibration of circular-segment-shaped membranes and plates of rectangular ortho-

tropy. A circular-segment-shaped membrane is formed on an orthotropic rectangular membrane by fixing several segments. With the reaction forces acting on the edges of an actual membrane regarded as unknown harmonic loads, the stationary response of the membrane to these loads is expressed by the use of the Green's function. The force distribution along the edges is expanded into Fourier series with unknown coefficients, and the homogeneous equations for the coefficients are derived by restraint conditions on the edges.

83-2220

Direct Method on the Determination of Eigenfrequencies of Arbitrarily Shaped Plates

K. Nagaya
Dept. of Mech. Engrg., Faculty of Engrg., Gunma Univ., Kiryu, Gunma, Japan, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 132-136 (Jan 1983) 4 figs, 6 tables, 17 refs

Key Words: Plates, Natural frequencies, Vibration analysis

A method for solving vibration problems of arbitrarily shaped plates is presented. The frequency equation for determining eigenfrequencies of arbitrarily shaped plates is given. A method of numerical calculation has been presented for five examples of circular plates, elliptical plates, rectangular plates with rounded corners, and cardioidal plates. Numerical calculations are carried out for rectangular plates with semicircular sides, rectangular plates with rounded corners and cardioidal plates. The results obtained by this method are compared with previously published results for typical cases of circular and rectangular plates.

83-2221

A Method for Obtaining Stress Intensity Factor by F.E.M. and Its Application to Dynamic Problem (Part 2, A Treatment for Mixed Mode Cracks)

H. Wada, Y. Takagi, and T. Nishimura
Daido Inst. of Tech., Minami-ku, Nagoya, Japan, Bull. JSME, 26 (215), pp 686-691 (May 1983) 12 figs, 3 tables, 23 refs

Key Words: Plates, Rectangular plates, Crack propagation

A new method recently proposed for obtaining stress intensity factors for opening mode cracks has now been extended to calculation of stress intensity factors for sliding mode cracks. The usefulness of the method has been tested with a number of rectangular plates having oblique straight cracks of various inclinations and lengths.

83-2222

Resonant Acoustic Frequencies of Flat Plate Cascades

W. Koch
DFVLR/AVA Institut f. Theoretische Stromungsmechanik, Bunsenstrasse 10, D-3400 Gottingen, Fed. Rep. Germany, J. Sound Vib., 88 (2), pp 233-242 (May 22, 1983) 5 figs, 14 refs

Key Words: Plates, Cascades, Vortex-induced vibration, Vortex shedding, Resonant frequencies

The analytical Wiener-Hopf solution is used to compute the resonant acoustic frequencies of a flat plate cascade as the natural frequencies of the system. For zero mean flow Mach number and unstaggered cascades Parker's results are recovered. New results are presented for staggered cascades and non-zero mean flow.

83-2223

Numerical Evaluation of the Radiation from Unbaffled, Finite Plates Using the FFT

E.G. Williams
Naval Res. Lab., Code 5133, Washington, DC 20375, J. Acoust. Soc. Amer., 74 (1), pp 343-347 (July 1983) 4 figs, 11 refs

Key Words: Disks (shapes), Plates, Vibrating structures, Noise generation, Fast Fourier transform

An iteration technique is described which numerically evaluates the acoustic pressure and velocity on and near unbaffled, finite, thin plates vibrating in air. The technique is based on Rayleigh's integral formula and its inverse. These formulas are written in their angular spectrum form so that the fast Fourier transform algorithm may be used to evaluate them. As an example of the technique the pressure on the surface of a vibrating, unbaffled disk is computed and shown to be in excellent agreement with the exact solution using oblate spheroidal functions.

83-2224

On-Line Spectral Control and Rotating Circular Discs Using Thermal Membrane Stresses

A. Rahimi

Ph.D. Thesis, Univ. of California, Berkeley, 170 pp (1982)
DA8312942

Key Words: Disks (shapes), Circular saws, Saws, Active vibration control

Rotating circular discs are widely used basic elements in many different machines such as gas and steam turbines, circular saws and computer memory discs. Large vibration amplitude of circular discs due to transverse instability can cause inaccurate cutting in circular saws, head tracking error in computer disc memories and failure of turbine wheels due to wheel-to-case contact. In this study, a new approach is described where a feedback control system continuously monitors the stability of circular discs by means of induced thermal membrane stresses in the plate. Although focused on circular saws, this work has application in all the above systems.

83-2225
An Investigation of Dual Mode Phenomena in a Mistuned Bladed Disk
W.A. Stange and J.C. MacBain
Air Force Aero Propulsion Lab., Turbine Engine Div., Wright-Patterson AFB, OH 45433, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 402-407 (July 1982) 13 figs, 1 table, 5 refs

Key Words: Blades, Disks (shapes), Tuning, Resonant response, Natural frequencies, Mode shapes

Results of an investigation addressing the effects of mistuning on the lower modes of vibration of a simple bladed-disk model are presented. The phenomena of dual modes, also known as mode splitting, is studied using holographic interferometry and strain gage measurements under nonrotating and rotating conditions.

SHELLS

83-2226
Mechanics and Behaviour of Hollow Cylindrical Members in Rolling Contact
C.S.C. Murthy and A.R. Rao
Mechanical Engrg. Dept., Indian Inst. of Tech., Madras 600036 India, Wear, 87, pp 287-296 (1983) 14 figs, 1 table, 15 refs

Key Words: Cylindrical shells, Cylinders, Rolling friction, Fatigue life, Rolling contact bearings

The mechanics of contact of hollow cylindrical elements were studied. The maximum contact stress is less for a hollow cylinder than for a solid cylinder. A simple numerical method is proposed to estimate the reduced contact stress by finding an equivalent modulus of elasticity for the hollow cylinder for use in the contact stress equation.

RINGS

83-2227
Inplane Vibrations of Circular Rings with a Radially Variable Thickness
H. Lecoanet and J. Piranda
Laboratoire de Mecanique Appliquée associé au CNRS, Faculté des Sciences, 25030 Besancon Cedex, France, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 137-143 (Jan 1983) 6 figs, 7 refs

Key Words: Rings, Circular rings, Variable cross-section, Galerkin method

Results on inplane vibrations of circular rings with radially variable thickness are presented. The problem is solved with the Galerkin method making use of the eigenfunctions of a constant thickness ring. Good agreement is obtained between the approximate results and those of the exact calculus or experimental data.

PIPES AND TUBES
(Also see Nos. 2213, 2214)

83-2228
Study on Modeling of Pipe Whipping by Finite Element Method
N. Miyazaki, S. Ueda, R. Kurihara, K. Saito, and R. Kato
Japan Atomic Energy Res. Inst., Tokyo, Japan, Rept. No. JAERI-M-9752, 47 pp (Oct 1981)
DE82702914

Key Words: Piping systems, Whipping phenomena, Finite element technique, Computer programs

The general purpose finite element codes ADINA and MARC were used to make a preliminary analysis for pipe whip tests

performed with use of 4B, sch80 test pipes under saturated water conditions. In the analyses, various models of the test pipe and the restraints were employed to study the effect of modeling on pipe whip behavior.

83-2229

Experimental Studies of Damping and Hydrodynamic Mass of a Cylinder in Confined Two-Phase Flow

L.N. Carlucci and J.D. Brown
Chalk River Nuclear Labs., Atomic Energy of Canada Ltd., Chalk River, Ontario, Canada, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 83-88 (Jan 1983) 10 figs, 4 refs

Key Words: Cylinders, Tubes, Tube arrays, Heat exchangers, Fluid-induced excitation, Damping coefficients, Mass coefficients

This paper presents the results of experiments done to determine the effects of cylinder mass and flow regime on the damping and hydrodynamic mass characteristics of a cylinder vibrating in simulated two-phase air-water flows. It was found that two-phase damping varied in inverse proportion to the combined cylinder and two-phase hydrodynamic masses.

83-2230

Flow-Induced Vibrations of Heat Exchanger U-Tubes: A Simulation to Study the Effects of Asymmetric Stiffness

D.S. Weaver and D. Koroyannakis
Dept. of Mech. Engrg., McMaster Univ., Hamilton, Ontario, Canada, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 67-75 (Jan 1983) 12 figs, 4 tables, 15 refs

Key Words: Tubes, Tube arrays, Heat exchangers, Fluid-induced excitation, Stiffness effects, Experimental test data

A water tunnel study was conducted to study the effect of asymmetric stiffness on a parallel triangular array of tubes with a pitch ratio of 1.375. The tubes were cantilevered from rectangular support rods so that the stiffness, and hence natural frequencies, were different in directions parallel and transverse to the flow. This arrangement was designed to simulate the difference in in-plane and out-of-plane natural frequencies of curved tubes.

83-2231

The Effect of Approach Flow Direction on the Flow-Induced Vibrations of a Triangular Tube Array

H.C. Yeung and D.S. Weaver
BHRA Fluid Engrg., Cranfield, Bedford, UK, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 76-82 (Jan 1983) 10 figs, 15 refs

Key Words: Tubes, Tube arrays, Heat exchangers, Fluid-induced excitation

Water tunnel experiments were conducted on an equilateral triangular array of tubes with a pitch ratio of 1.5. Eight tests were run with different array orientations so that the effects of incident flow direction on crossflow induced vibrations could be studied. Small amplitude vorticity response was observed for all orientations except the parallel triangular array.

DUCTS

83-2232

Acoustic Loading in Planar Networks

M. El-Raheb and P. Wagner
Jet Propulsion Lab., California Inst. of Tech., Pasadena, CA 91109, J. Sound Vib., 88 (2), pp 151-162 (May 22, 1983) 8 figs, 8 refs

Key Words: Ducts, Branched systems, Noise generation

The acoustic loading in a complex planar network of ducts is determined by a method in which Green function surface elements are used. The network consists of straight ducts, elbows and branched ducts. A transfer matrix technique is developed in which each duct is treated separately and the matrix of the influence coefficients is transformed to tridiagonal form allowing efficient inversion.

83-2233

Wave Propagation in Strongly Curved Ducts

D.H. Keefe and A.H. Benade
Dept. of Physics, Case Western Reserve Univ., Cleveland, OH 44106, J. Acoust. Soc. Amer., 74 (1), pp 320-332 (July 1983) 8 figs, 3 tables, 14 refs

Key Words: Ducts, Curved ducts, Wave propagation, Sound waves

A theoretical and experimental investigation is made of wave propagation in the long-wavelength limit in curved ducts of both rectangular and circular cross section. The two-dimensional solution of the wave equation for propagation in curved rectangular bends is adapted for the case of a circular cross section. The wave admittance and phase velocity are computed in terms of integrals over the cross section of the duct in which there is a radial variation in flow. Experiments to measure the wave admittance and phase velocity are carried out with semicircular segments from a baritone horn musical instrument tuning slide.

BUILDING COMPONENTS

(Also see No. 2345)

83-2234

Seismic Analysis of Slender Coupled Walls

J.D. Aristizabal-Ochoa

Vanderbilt Univ., Nashville, TN 37235, ASCE J. Struc. Engrg., 109 (7), pp 1538-1552 (July 1983) 10 figs, 1 table, 11 refs

Key Words: Walls, Reinforced concrete, Seismic analysis

The dynamic response of multistory reinforced concrete coupled walls was evaluated from the perspective of linear models based on response spectra, modal analysis, and reduced effective stiffnesses.

83-2235

On the Three-Dimensional Vibrations of the Cantilevered Rectangular Parallelepiped

A. Leissa and Zhong-ding Zhang

Dept. of Engrg. Mech., Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 73 (6), pp 2013-2021 (June 1983) 5 figs, 5 tables, 12 refs

Key Words: Natural frequencies, Mode shapes, Parallelepiped, Cantilever beams, Ritz method

A solution is presented for the three-dimensional problem of determining the free vibration frequencies and mode shapes for a rectangular parallelepiped which is completely fixed on one face and free on the other five faces. The Ritz method is used, with displacement assumed in the form of algebraic polynomials. Convergence is studied. Numerical results are given for the first five frequencies of each of the four symmetry classes of vibration, for five thick parallelepiped configurations, including the cube. Contour plots are exhibited for the modal displacements of the cube. The effects of varying Poisson's ratio are also observed.

ELECTRIC COMPONENTS

GENERATORS

83-2236

Electromagnetic Forces on the End Windings of Large Turbine Generators. II. Transient Conditions

S.J. Salon, D.J. Scott, and G.L. Kusic

Rensselaer Polytechnic Inst., Troy, NY 12181, IEEE Trans., Power Apparatus Syst., PAS-102 (1), pp 14-19 (Jan 1983) 19 figs, 3 refs

Key Words: Generators, Electromagnetic excitation, Transient response

A companion paper explained the basic concepts of end winding forces during steady state and gave examples of the variation of force with power factor. This paper extends the analysis to transient operation. The fields and currents are represented in the dqo reference frame. The fields are then projected onto the coil zones, and the cross-product is taken in order to find the force. Several examples are given in which the instantaneous force is calculated.

83-2237

Operational Inductances of Turbine-Generators by the Finite-Element Method

S.H. Minnich, M.V.K. Chari, and J.F. Berkery

General Electric Co., Schenectady, NY, IEEE Trans., Power Apparatus Syst., PAS-102 (1), pp 20-27 (Jan 1983) 6 figs, 17 refs

Key Words: Finite element technique, Intake systems, Generators

A method is developed for calculating small-signal, terminal, operational inductances. The method is based on solutions to the magnetic diffusion equation by the finite-element method. To faithfully simulate the behavior of the rotor iron for small signal perturbations, measured values for incremental permeability are used. A finite-element grid tailored to handle the skin effect at frequencies up to 100 hertz is developed.

DYNAMIC ENVIRONMENT

ACOUSTIC EXCITATION

(Also see Nos. 2172, 2309, 2311)

83-2238

Coherent Attenuation of Acoustic Waves by Pair-Correlated Random Distribution of Scatterers with Uniform and Gaussian Size Distributions

V.K. Varadan, V.N. Bringi, V.V. Varadan, and Y. Ma
Wave Propagation Group, Dept. of Engrg. Mech., The Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 73 (6), pp 1941-1947 (June 1983) 10 figs, 32 refs

Key Words: Sound waves, Wave attenuation, Wave diffraction

Acoustic wave attenuation due to multiple scattering in a two-phase medium consisting of a fluid with embedded rigid, fluid, or elastic particles of varying sizes is discussed. The formulation, involving the exciting and scattered fields of an incident acoustic plane wave, is based on the T-matrix method. The propagation features of coherent waves in the mixture are described by the dispersion equation which is derived by applying standard statistical approximations to the discrete random medium.

83-2239

Effect of Finite Ground Impedance on the Propagation of Acoustic Pulses

R. Raspet, H.E. Bass, and J. Ezell
U.S. Army Construction Engrg. Res. Lab., Box 4005, Champaign, IL 61820, J. Acoust. Soc. Amer., 74 (1), pp 267-274 (July 1983) 9 figs, 19 refs

Key Words: Sound waves, Wave propagation, Explosions

The propagation of an acoustic transient in the vicinity of a finite impedance ground plane has been numerically simulated. A waveform characteristic of a small explosive charge was selected for analysis. Pulse waveforms and amplitudes were computed for propagation distances from 3 to 3000 m, for microphone heights from 0 to 30 m, and for flow resistances from 10 to 1000 g cm^{-3} s^{-1}. This study indicates that finite ground impedance can significantly affect acoustic pulses from explosives.

83-2240

Normal Mode Scaling and Phase Change at the Boundary

T.C. Yang
Naval Res. Lab., Washington, DC 20375, J. Acoust. Soc. Amer., 74 (1), pp 232-240 (July 1983) 8 figs, 8 refs

Key Words: Underwater sound, Sound propagation, Group velocity, Normal modes, Scaling

The group velocities of normal modes are not independent but are related to each other by a scaling law. The scaling law relates the frequencies of any two modes received at a particular time (associated with a particular group velocity) by a scaling parameter. The scaling parameter is a constant for mode energies fully contained in the water column; in the ray picture, this corresponds to refracted only, and refracted and surface reflected rays. Experimental data is analyzed to see how well the constant behaves for a variety of frequencies and modes.

83-2241

Slope Propagation: Mechanisms and Parameter Sensitivities

R.A. Koch, S.R. Rutherford, and S.G. Payne
Applied Res. Labs., The Univ. of Texas at Austin, Austin, TX 78712, J. Acoust. Soc. Amer., 74 (1), pp 210-218 (July 1983) 18 figs, 7 refs

Key Words: Underwater sound

An adiabatic normal mode analysis is used to identify cylindrical spreading, renormalization, bottom attenuation, differential mode excitation and reception, and mode cutoff as major physical mechanisms influencing underwater acoustic propagation over slopes. Propagation is sensitive to the shallow water sediment attenuation but not to the slope angle.

83-2242

S-Matrix and Acoustic Signal Structure in Simple and Compound Waveguides

C.H. Wilcox
Dept. of Mathematics, Univ. of Utah, Salt Lake City, UT, Rept. No. TSR-45, 43 pp (Dec 1982) AD-A125 583

Key Words: Waveguide analysis, Sound waves, Wave propagation

This paper deals with the propagation of transient acoustic fields in waveguides that consist of a semi-infinite cylinder coupled to a resonant cavity or resonator. The walls of the waveguide are assumed to be rigid. The sources of the transient sound fields, or signals, are assumed to be localized in a bounded portion of the waveguide and to act for a finite interval of time. The goal of the work is to calculate such acoustic signals and to analyze how their structure depends on the sources and the geometry of the waveguide.

83-2243

Normal-Mode Propagation in Deep-Ocean Sediment Channels: A Sequel

A.O. Williams, Jr.

Dept. of Physics, Naval Postgraduate School, Monteray, CA 93940, J. Acoust. Soc. Amer., 73 (6), pp 1985-1988 (June 1983) 1 fig, 7 refs

Key Words: Underwater sound, Wave propagation, Sound waves

The present writer has discussed various aspects of propagation in sediment channels. A simplifying assumption was that c_ω, the speed of sound in the water, is constant everywhere. In this sequel it is more realistically assumed that c_ω decreases slowly and linearly with height above the water-sediment interface. Consequently an acoustic barrier exists from the interface to, typically, 100-200 m above it. Equations are derived to describe the acoustic field both in and above the barrier, and a long-known method yields the amplitude attenuation factor caused by leakage.

83-2244

Acoustic Shadowing by an Isolated Seamount

N.R. Chapman and G.R. Ebbeson

Defence Research Establishment Pacific, FMO, Victoria, British Columbia, Canada V0S 1B0, J. Acoust. Soc. Amer., 73 (6), pp 1979-1984 (June 1983) 11 figs, 10 refs

Key Words: Underwater sound, Sound waves, Wave propagation

Acoustic shadowing by an isolated seamount has been studied by examining the multipath propagation measurements obtained in a shot run that passed over the seamount peak. Source depths of 24 and 196 m were used in the experiment. In the acoustic shadow, the propagation loss for the shallow 24-m shots increased by 10-15 dB over the loss expected in the absence of the seamount.

83-2245

Nonlinear Mixing of Surface Acoustic Waves Propagating in Opposite Directions

N. Kalyanasundaram

Dept. of Electronics and Communication Engrg., Regional Engrg. College, Tiruchirapalli 620015, India, J. Acoust. Soc. Amer., 73 (6), pp 1956-1965 (June 1983) 4 figs, 10 refs

Key Words: Sound waves, Wave propagation

The parametric mixing of two modulated surface acoustic waves propagating in opposite directions is studied with reference to nonlinear signal processing applications by the coupled mode theory of nonlinear surface waves.

83-2246

Recommendations for the Acoustic Treatment of Cumbica International Airport

Internacional de Engenharia, Sao Paulo, Brazil, Rept. No. IESA-144-83, 70 pp (Jan 32, 1983)

N83-19578

(In Portuguese)

Key Words: Airports, Noise reduction

The report presents the various alternatives that are recommended to keep the noise level in the airport terminal areas within acceptable values. Discussions on the acoustic isolation and absorption materials are presented indicating which ones should be used and which ones should not. Adequate materials for use in noise isolation are discussed.

83-2247

Farfield Inflight Measurement of High-Speed Turboprop Noise

J.R. Balombin and I.J. Leoffler

NASA Lewis Res. Ctr., Cleveland, OH, Rept. No. NASA-TM-83327, 19 pp (1982))Presented at the AIAA 8th Aeroacoustics Conf., Atlanta, Apr 11-13, 1983)

N83-21895

Key Words: Propeller noise, Noise measurement

A flight program was carried out to determine the variation of noise level with distance from a model high speed propeller. Noise measurements were obtained at different dis-

tances from a SR-3 propeller mounted on a JetStar aircraft, with the test instrumentation mounted on a Lear jet flown in formation.

83-2248

Paper Forms Skip Noise in Printers

L.W. Brehm
International Business Machines Corp., Dept. D68, P.O. Box 6, Endicott, NY 13760, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 61-70, 12 figs

Key Words: Printing, Noise generation

Noise radiating from paper forms generating from vibrations caused by line spacing – or "skip" of the forms – and by impact printing is investigated. These vibrations propagate through the paper and then from the curved surfaces of the forms as airborne noise. Where the forms exit to locations outside of the printer cover, this noise may be especially offensive. Impact printing noise predominates in the 4 and 8 kHz octave bands.

83-2249

Noise Sources and Noise Reduction in Office Machines

E. Schaffert
BeSB GmbH Berlin, Holmholtzstr. 9, 100 Berlin 10, Fed. Rep. Germany, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 71-80, 9 figs

Key Words: Printing, Noise reduction

The principles of noise generationg by the printing systems of office machines were investigated in several research programs. The aim of these investigations was to reduce the generated noise by so called primary measures; i.e., measures which reduce noise generation at the source. This requires the accurate knowledge of noise generating mechanisms.

83-2250

Production Line Noise Testing Using Vibration Techniques

R.G. Cann
Grozier Technical Systems, Inc., 157 Salisbury Rd., Brookline, MA 02146, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 91-98, 8 figs, 3 refs

Key Words: Household appliances, Noise measurement, Vibration tests

Once the desirable sound level of a new product is established by psychoacoustical means, there is a need for monitoring its sound level on the production line. The simple sound test, when applied to the production line, may be either uselessly accurate or undesirably expensive. Using the sewing machine as an example, it has been shown, through extensive empirical work, that the sound test can be profitably replaced by a vibration test.

83-2251

An Analytical and Experimental Study of the Acoustical Noise Produced by Machine Links

S. Dubowsky and T.L. Morris
Univ. of California, Los Angeles, CA 90024, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 393-401 (July 1982) 14 figs, 2 tables, 23 refs

Key Words: Machinery noise, Noise generation, Mathematical models

Noise from high-speed machine systems is an important engineering design problem. This study investigates a recently developed analytical technique for calculating the noise generated by linkage-type machines based both on recently developed analytical methods for modeling the dynamic response of machines and on classical acoustical theory. This acoustical-dynamic modeling method is applied to an experimental system with elastic elements and clearance connections; the analytically predicted acoustical fields are compared to the measured noise.

83-2252

Theoretical and Experimental Studies of the Noise Reduction of an Idealized Cabin Enclosure

V. Cole, M.J. Crocker, and P.K. Raju
Paul S. Veneklasen and Associates, 1711 16th St., Santa Monica, CA 90404, Noise Control Engrg.,

20 (3), pp 122-132 (May/June 1983) 10 figs, 24 refs

Key Words: Enclosures, Noise reduction

In-cab noise environment of commercial vehicles and its effect on operators and passengers is of much concern. The airborne noise reduction that can be achieved by such an enclosure is studied. Experimental measurements are performed in a reverberation chamber supplied with broadband white noise. The attenuation is measured in one-third octave bandwidths whose center frequencies ranged from 63 Hz to 20 kHz. From these results, conclusions are drawn as to the best ways of maximizing the noise reduction of cabin enclosures.

83-2253

Predictions of Low-Frequency Sound from the MOD-1 Wind Turbine

R. Martinez, S.E. Windall, and W.L. Harris
Dept. of Aeronautics and Astronautics, Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. SERI/TR-635-1247, 61 pp (Dec 1982)
DE83004410

Key Words: Noise prediction, Noise source identification, Noise-induced excitation, Wind turbines, Turbines

The purpose of this project was to determine if aerodynamic noise mechanisms are associated with the acoustic noise situation that results from the operation of the MOD-1 wind turbine. The possible sources of aeroacoustic noise studied were steady blade loads, unsteady blade loads due to wind shear, and unsteady loads on the blades as they pass through the tower wake. Mathematical models that were used to study these noise sources are described.

83-2254

Generation of Acoustic Waves by an Impulsive Line Source in a Fluid/Solid Configuration with a Plane Boundary

A.T. deHoop and J.H.M.T. Van Der Hijden
Schlumberger-Doll Research, P.O. Box 307, Ridgefield, CT 06877, J. Acoust. Soc. Amer., 74 (1), pp 333-342 (July 1983) 8 figs, 3 tables, 14 refs

Key Words: Sound generation, Line source excitation, Interface: solid-fluid

The space-time acoustic wave motion generated by a two-dimensional, impulsive, monopole line source in a fluid/solid configuration with a plane boundary is calculated with the aid of the modified Cagniard technique. The source is located in the fluid, and numerical results are presented for the reflected-wave acoustic pressure, especially in those regions of space where head wave contributions occur.

83-2255

Time Domain Study of the Terminated Transient Parametric Array

N.G. Pace and R.V. Ceen
School of Physics, Univ. of Bath, Claverton Down, Bath BA2 7AY, UK, J. Acoust. Soc. Amer., 73 (6), pp 1972-1978 (June 1983) 9 figs, 13 refs

Key Words: Acoustic arrays, Impulse response, Time domain method

A spatial impulse response model of the parametric array is developed and used to give physical insight into its behavior when operated in a transient mode. Experimental measurements of the spatial dependence of the acoustic pressure waveforms produced by the transient parametric array are compared with the result of the convolution of the spatial impulse response with the specific pressure waveforms used. Particular emphasis is given to the case where the primary field is discontinuously terminated.

83-2256

Helmholtz Resonators. 1975 - April, 1983 (Citations from the International Information Service for the Physics and Engineering Communities Data Base)

NTIS, Springfield, VA, 68 pp (Apr 1983)
PB83-861930

Key Words: Acoustic measurement, Acoustic impedance, Helmholtz resonators, Bibliographies

This bibliography contains 54 citations concerning the measurement and analysis of acoustic impedance utilizing Helmholtz resonators. Two-dimensional Helmholtz resonators, biological effects of acoustical stimulii, Helmholtz resonator utilization for continuous pipe flow measurement, detection and analysis of acoustic room insulation, viscous losses, and optoacoustic phenomena are among the topics discussed. Applications and performance evaluations are considered.

83-2257

Acoustic Ground Impedance Meter

A.J. Zuckerwar

NASA Langley Res. Ctr., Hampton, VA 23665, J. Acoust. Soc. Amer., 73 (6), pp 2180-2186 (June 1983) 7 figs, 1 table, 25 refs

Key Words: Acoustic impedance, Ground motion, Helmholtz resonators

A compact, portable instrument has been developed to measure the acoustic impedance of the ground, or other surfaces, by direct pressure-volume velocity measurement. A Helmholtz resonator, constructed of heavy-walled stainless steel but open at the bottom, is positioned over the surface having the unknown impedance. The prototype instrument can measure specific ground impedance at normal incidence up to 50 times the specific impedance of air. Detailed design criteria and results of measurements on an uncultivated grass field are presented.

83-2258

Acoustic High-Frequency Scattering by Elastic Cylindrical Shells

J.W. Dickey, D.A. Nixon, and J.M. D'Archangelo David Taylor Naval Ship R&D Ctr., Annapolis, MD 21402, J. Acoust. Soc. Amer., 74 (1), pp 294-304 (July 1983) 11 figs, 19 refs

Key Words: Shells, Cylindrical shells, Acoustic scattering

Acoustical scattering resulting from a high-freuqency plane-wave incident upon an infinite aluminum circular cylindrical shell immersed in and filled with water is determined by applying the Sommerfeld-Watson transformation to the classical Rayleigh normal-mode series solution. The resulting contour integrals are computed by both the saddle point method and by summing residues over poles which correspond to the zeros of a 6 x 6 determinant resulting from satisfying the necessary boundary conditions. Emphasis is placed on the transitions in the scattering characteristics as the shell goes from a solid cylinder to a thin-walled shell.

SHOCK EXCITATION

(Also see Nos. 2316, 2345)

83-2259

Experimental Study into the Scaling of an Unswept-Sharp-Fin-Generated Shock/Turbulent Boundary Layer Interaction

W.B. McClure

Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/CI/NR-83-6T, 123 pp (Jan 1983) AD-A126 919

Key Words: Interaction: shock waves-boundary layer, Experimental test data, Scaling

An experimental study was carried out on a three-dimensional shock wave/turbulent boundary layer flow-field generated by sharp fin with an unswept leading edge at a 10 deg angle-of-attack to the incoming flow. The objectives of this study were to learn more about the structure of this type of interaction, to examine the scaling of the resulting flow-field, and to obtain a detailed data set with which to compare numerical computations.

83-2260

Earthquake Engineering Research - 1982

Committee on Earthquake Engrg. Res., National Res. Council, Washington, D.C., Rept. No. CETS-CEER-001B, 281 pp (1982) and Rept. No. CETS-CEER-001A, 94 pp (1982)

PB83-176032 and PB83-176024

Key Words: Seismic design, Interaction: structure-fluid

Two questions were addressed: what progress has research produced in earthquake engineering and which elements of the problem should future earthquake engineering pursue. Examined and reported in separate chapters of the report: applications of past research, assessment of earthquake hazard, earthquake ground motion, soil mechanics and earth structures, analytical and experimental structural dynamics, earthquake design of structures, seismic interaction of structures and fluids, social and economic aspects, earthquake engineering education, research in Japan.

83-2261

Dynamic Analysis of Landing Impact

Engrg. Div., Israel Aircraft Industries Ltd., Tel-Aviv, Israel, Rept. No. IAITIC-82-1006, 12 pp (Jan 1982) PB83-188383

Key Words: Landing gear, Impact shock, Shock absorbers

This paper describes a series of analyses that were developed to calculate loads and displacements of landing gear systems having a variety of configurations. The mathematical models

used in these analyses simulate the dynamics of landing impact and account for such effects as: nonlinear shock-absorber stiffness; hydraulic damping of the shock-absorber; shock-absorber internal friction; fore-and-aft flexibility of the landing gear leg; tire/ground friction characteristics; wheel spin-up effects. By means of numerical integration, time-histories of landing gear loads and displacements are calculated.

83-2262

Cyclic Loading of Spirally Reinforced Concrete

S.P. Shah, A. Fafitis, and R. Arnold

Northwestern Univ., Evanston, IL 60201, ASCE J. Struc. Engrg., 109 (7), pp 1695-1710 (July 1983) 14 figs, 3 tables, 20 refs

Key Words: Reinforced concrete, Seismic excitation, Cyclic loading

The concept of the envelope curve which was based primarily on plain concrete is extended to confined concrete subjected to cyclic loading. Spirally confined normal weight and light weight concrete specimens are subjected to stress and strain cycling loadings at low as well as high strain rates. Analytical expressions are developed to predict the envelope curve as well as the peak strength and the corresponding strain.

83-2263

Properties of Concrete Subjected to Impact

W. Suaris and S.P. Shah

Univ. of Miami, Coral Gables, FL, ASCE J. Struc. Engrg., 109 (7), pp 1727-1741 (July 1983) 8 figs, 3 tables, 20 refs

Key Words: Concretes, Impact response, Impulse response, Dynamic tests, Experimental test data

For rational design of concrete structures subjected to impact and impulsive loading, the constitutive properties of concrete over a wide range of strain rates are required. With this aim in mind, concrete and fiber reinforced concrete beams were tested in a drop-weight, instrumented impact testing machine. During the impact event, loads, deflections and strains were monitored. The influence of matrix mix proportions, relative humidity during curing and the type of fibers (steel, polypropylene and glass) on impact properties are presented.

83-2264

Dynamic Stability of a Vibrating Hammer

J. Inoue and S. Miyaura

Kyushu Univ., Higashi-ku Fukuoka, Japan, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 321-325 (July 1983) 8 figs, 3 refs

Key Words: Hammers, Vibrating structures, Energy absorption, Motors, Dynamic stability

This paper deals with the stability of motion of an elastically suspended vibrating hammer that impacts upon an energy absorbing surface referring to the dynamical interaction between a vibrating hammer and a motor.

83-2265

Transfer Functions and Impulse Responses of Rigid and Elastic Spheres (Fonctions de transfert et réponses impulsionnelles de sphères rigides et élastiques)

C. Gazanhes, J.P. Sessarego, J.P. Herault, and J. Leandre

Laboratoire de Mecanique et d'Acoustique (CNRS), BP 71, F-13277 Marseille Cedex 9, France, Acustica, 52 (5), pp 265-272 (Apr 1983) 7 figs, 2 tables, 11 refs

(In French)

Key Words: Spheres, Impulse response, Transfer functions

The transfer functions and the impulse responses of rigid and elastic spheres are investigated for values of the reduced parameter ka from 0.2 up to 28. These functions are calculated initially from modal theory and then verified experimentally from back-scattering measurements. For rigid spheres some examples are given of impulse responses derived by different techniques and the influence of creeping waves is discussed. For elastic spheres a smoothed impulse response is computed by taking the inverse Fourier transform of the transfer function.

VIBRATION EXCITATION

(Also see Nos. 2164, 2235, 2311)

83-2266

Design of the Flutter Suppression System for DAST ARW-1R

J.R. Newsom, A.S. Pototzky, and I. Abel

NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-84642, 15 pp (Mar 1983) (Presented at the AIAA/ASME/ASCE AHS 24th Struct., Struct. Dyn. and Mater. Conf., Lake Tahoe, NV, May 2-4, 1983)
N83-21840

Key Words: Flutter, Active flutter control, Aircraft

The design of the flutter suppression system for a remotely-piloted research vehicle is described. The modeling of the aeroelastic system, the methodology used to synthesize the control law, the analytical results used to evaluate the control law performance, and ground testing of the flutter suppression system on-board the aircraft are discussed. The major emphasis is on the use of optimal control techniques employed during the synthesis of the control law.

83-2267

Nonlinear Extensional Vibrations of Quartz Rods

H.F. Tiersten and A. Ballato

Dept. of Mech. Engrg., Aeronautical Engrg. and Mechanics, Rensselaer Polytechnic Inst., Troy, NY 12181, J. Acoust. Soc. Amer., 73 (6), pp 2022-2033 (June 1983) 5 figs, 21 refs

Key Words: Nonlinear vibration, Longitudinal vibration, Quartz crystals, Piezoelectricity

The one-dimensional scalar differential equation describing the extensional motion of thin piezoelectric rods is obtained from the general nonlinear three-dimensional description. Only the elastic nonlinearities are considered. The relations between the quadratic and cubic coefficients of the rod and the fundamental anisotropic elastic constants of various orders are derived.

83-2268

Vibration Transmission in Machine Structures

R.H. Lyon

Massachusetts Inst. of Tech., Dept. of Mech. Engrg., Cambridge, MA 02139, Noise Control Engrg., 20 (3), pp 92-103 (May/June 1983) 14 figs, 25 refs

Key Words: Vibration transfer, Transfer functions, Machinery

There is growing interest in the use of vibration signals for diagnostics and phase retention is very important in this area. A theoretical description of sources of vibration and how they are measured is summarized. Discrepancy between the *(theoretically) desirable information and commonly avail*able data is highlighted. A description of the transmission path in terms of dispersion, multipath propagation and reverberation that affect the transmitted vibration signal is considered.

83-2269

Investigation of Limit Cycle Response of Aerodynamic Surfaces with Structural Nonlinearities

R.P. Briley and J.L. Gubser

McDonnell Douglas Astronautics Co., East St. Louis, MO, Rept. No. AFOSR-TR-83-0232, 65 pp (Oct 1, 1983)
AD-A127 140

Key Words: Aerodynamic stability, Limit cycle analysis, Nonlinear theories

Aerodynamic surface design must often account for the presence of structural nonlinearities induced by freeplay in the support structure and/or control actuators. During this study, application of asymptotic expansion methods to predict the limit cycle behavior of aerodynamic surfaces with structural nonlinearities was investigated.

83-2270

Aerodynamics of Airfoils Subject to Three-Dimensional Periodic Gusts

H. Atassi

Dept. of Aerospace and Mech. Engrg., Notre Dame Univ., IN, Rept. No. AFOSR-TR-83-0231, 68 pp (July 1982)
AD-A127 043

Key Words: Airfoils, Wind-induced excitation, Turbulence, Turbomachinery

This report outlines research on unsteady aerodynamics and stability analysis of turbomachine components and its relevance to ongoing technological developments in turbomachine design. The main topic of this research is the unsteady aerodynamics of lifting airfoils subject to three-dimensional gusts.

83-2271

Rotary Oscillations of a Spheroid in an Incompressible Micropolar Fluid

S.K. Lakshmana Rao and T.K.V. Iyengar
Dept. of Mathematics, Regional Engrg. College, Warangal-506004, India, Intl. J. Engrg. Sci., 21 (8), pp 973-987 (1983) 5 refs

Key Words: Spheres, Vibrating structures, Fluids

The flow generated by rotary oscillations of a spheroid (prolate and oblate) in incompressible micropolar fluid is discussed. The velocity and microrotation components are determined explicitly in terms of spheroidal wave functions and are expressed in infinite series form. The couple on the oscillating spheroid is evaluated and numerical studies are undertaken to examine the effects of the geometric parameter and material constant parameters of the fluid.

83-2272

An Efficient Technique for the Approximate Analysis of Vibro-Impact

R.K. Miller and B. Fatemi
Dept. of Civil Engrg., Univ. of Southern California, Los Angeles, CA 90007, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 332-336 (July 1983) 6 figs, 11 refs

Key Words: Vibro-impact systems, Base excitation, Harmonic excitation

An approximate solution procedure is presented for a class of steady vibro-impact problems consisting of adjacent structures separated by a gap and subjected to harmonic base excitation. The procedure is based on a weighted mean-square linearization technique, and is capable of substantial reduction of computational effort over that required for an exact numerical simulation. A detailed analysis of an example problem is presented together with a comparison of results with an exact solution.

83-2273

Quick Vibration Analysis of Four-Mass Systems

R. Errichello
Gear Consultant, GEARTECH, Albany, CA, Mach. Des., 55 (13), pp 110, 112, 115 (June 9, 1983) 1 fig

Key Words: Vibration analysis, Multi-degree of freedom systems

A method of mathematical substitution is presented by which the dynamic properties of a four-mass mechanical system can be evaluated quickly in a closed form, eliminating the need for numerical iterations.

83-2274

Parametrically Excited Multidegree-of-Freedom Systems with Repeated Frequencies

A.H. Nayfeh
Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 88 (2), pp 145-150 (May 22, 1983) 8 refs

Key Words: Multidegree-of-freedom systems, Parametric excitation

An analysis is presented of the linear response of multidegree-of-freedom systems with a repeated frequency of order three to a harmonic parametric excitation. The method of multiple scales is used to determine the modulation of the amplitudes and phases for two cases: fundamental resonance of the modes with the repeated frequency and combination resonance involving these modes and another mode. Conditions are then derived for determining the stability of the motion.

83-2275

Stability Boundary for Pseudo-Random Parametric Excitation of a Linear Oscillator

D. Watt and A.D.S. Barr
The University, Dundee, DD1 4HN, UK, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 326-331 (July 1983) 8 figs, 1 table, 24 refs

Key Words: Parametric excitation, Oscillators

Stability bounds are outlined for the null solution of the equation describing the response of a linear damped oscillator excited through periodic coefficients, the excitation being a form of Rice noise comprising equal amplitude sinusoids with frequencies at equal intervals in the vicinity of twice the natural frequency of the system, but with pseudo-random initial phases. Stability was investigated by the monodromy matrix method, which is exact apart from errors due to numerical integration, and by the approximate method due to Struble, which replaces the dependent variable by its amplitude and a phase variable.

83-2276

Turbulent Pressure-Velocity Measurements in a Fully Developed Concentric Annular Air Flow

R.J. Wilson and B.G. Jones
RAS Div., Argonne Natl. Lab., Argonne, IL 60439,
J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 345-354 (July 1983) 23 refs, 2 tables, 26 refs

Key Words: Fluid-induced excitation

An experimental study of the fluctuating velocity field and the fluctuating static wall pressure in an annular turbulent air flow system with a radius ratio of 4.314 has been conducted. The study included direct measurements of the mean velocity profile, turbulent velocity field and fluctuating static wall pressure from which the statistical values of the turbulent intensity levels, power spectral densities of the turbulent quantities, and the cross-correlation between the fluctuating static wall pressure and the fluctuating velocity field in the core region of the flow were obtained.

83-2277

Flow Instability Due to a Diameter Reduction of Limited Length in a Long Annular Passage

M.W. Parkin, E.R. France, and W.E. Boley
United Kingdom Atomic Energy Authority, Seascale, Cumbria CA201PF, UK, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 355-360 (July 1983) 13 figs, 5 refs

Key Words: Fluid-induced excitation, Nuclear reactor components

Flow in an annular passage is a common feature in the fuel channels of the UK advanced gas cooled reactors, and in some cases has required investigation to avoid or reduce flow-induced vibration of reactor components. A number of studies of vibration induced by annular flow are briefly reviewed in the first part of this paper. The second part of the paper describes the investigation of the most recently recognized problem of this type, which is a flow instability caused by a diameter reduction of limited length in a long annulus. A method of eliminating the mechanism is also described.

83-2278

Airfoil Shape and Thickness Effects on Transonic Airloads and Flutter

S.R. Bland and J.W. Edwards
NASA Langley Res. Ctr., Hampton, VA, Rept. No. NASA-TM-84632, 10 pp (Mar 1983) (Presented at the AIAA/ASME/ASCE/AHS 24th Struct., Struct. Dyn. and Mater. Conf., Lake Tahoe, NV, May 2-4, 1983)
N83-20912

Key Words: Airfoils, Flutter, Harmonic excitation, Geometric effects, Transient pulse technique

A transient pulse technique is used to obtain harmonic forces from a time-marching solution of the complete unsteady transonic small perturbation potential equation. The unsteady pressures and forces acting on a model of the NACA 64A010 conventional airfoil and the MBB A-3 supercritical airfoil over a range of Mach numbers are examined in detail.

83-2279

"Non-Linear Normal Modes" and the Generalized Ritz Method in the Problems of Vibrations of Non-Linear Elastic Continuous Systems

W. Szemplinska-Stupnicka
Inst. of Fundamental Technological Res., Polish Academy of Sciences, 00-049 Warsaw, Swietokrzyska 21, Poland, Intl. J. Nonlin. Mech., 18 (2), pp 149-165 (1983) 8 figs, 25 refs

Key Words: Mode shapes, Ritz method

In the study of natural vibrations of nonlinear elastic systems it is shown that the mode shape of the vibration can vary with the amplitude as well as the frequency, and that the amplitude-frequency relation is strongly affected by constraints imposed on the mode shape in an approximate solution. A method is developed which assumes the approximate solution in the form of a truncated series in which, instead of the set of coefficients, the set of functions of spatial variables is unknown and then determined by a procedure that can be regarded as a generalization of the Ritz method.

MECHANICAL PROPERTIES

DAMPING

(Also see No. 2200)

83-2280

Protection of Continuous Structures Against Vibrations by Active Damping

E. Luzzato and M. Jean
Centre National de la Recherche Scientifique, Laboratoire de Mecanique et d'Acoustique, 31, Chemin Joseph-Aiguier, Marseille, France, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 374-381 (July 1983) 16 figs, 12 refs

Key Words: Damping, Active damping, Vibration damping, Continuous systems, Viscoelastic properties, Flexural vibration, Beams, Plates

The problem of active damping of vibrations of a continuous viscoelastic structure is studied, and a general method of computation of the control system is developed. A mechanical model for this structure, sources of perturbing vibrations, the control system, and different absorption criteria are defined. Numerical results simulating the behavior of flexural vibrations in a rectangular plate, which is simply supported along the whole boundary, are presented for three different absorption criteria, thus permitting a quick evaluation of the comparative effectiveness of the chosen criteria.

83-2281
Power Turbine Dynamics -- An Evaluation of a Shear-Mounted Elastomeric Damper
E.S. Zorzi, J. Walton, and R. Cunningham
Mechanical Technology, Inc., Latham, NY, ASME Paper No. 83-GT-228

Key Words: Dampers, Elastomeric dampers, Rotating machinery

This successful application of elastomeric damper technology presents an opportunity to reflect upon the many uses of elastomers as alternatives to conventional squeeze-film dampers.

83-2282
Effect of Damping on Shock Response Spectrum
Y. Matsuzaki
National Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-739T, ISSN-0389-4010, 10 pp (Sept 1982) N83-19127

Key Words: Damping effects, Shock response spectra

The shock response spectrum of an oscillator with any amount of damping which is subjected to an arbitrary shock excitation is analyzed. The residual shock spectrum is also evaluated when a rectangular, triangular or half sine wave pulse is applied to the oscillator.

83-2283
Characterization of High Temperature Polymeric Damping Materials
R.P. Chartoff, I.O. Salyer, M.L. Drake, et al
Univ. of Dayton Res. Inst., Dayton, OH 45469, Rept. No. AFWAL-TR-82-4185, 246 pp (Jan 1983)

Key Words: Vibration damping, Energy absorption, Polymers

An exploratory development program was carried out to find polymer systems that are effective energy absorbers for vibration damping purposes in the temperature range from 300°F (149°C) to 700°F (371°C). The study concentrated on aromatic backbone structures of the type that were known to have good thermal stabilities and glass transitions falling in the temperature range of interest. Among the types of polymers considered were various polyimide, polysulfone, ATX, and silicone materials.

83-2284
Comparison of Equivalent Viscous Damping and Nonlinear Damping in Discrete and Continuous Vibrating Systems
J.P. Bandstra
Div. of Engrg. Tech., Univ. of Pittsburgh at Johnstown, Johnstown, PA 15904, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 382-392 (July 1982) 3 figs, 8 tables, 24 refs

Key Words: Damping, Viscous damping, Nonlinear damping, Continuous systems

The study of nonlinear damping in vibrations is motivated by the desire to represent and predict real responses more accurately than allowed by the limitations of linear analysis, since observed phenomena are, in general, actually nonlinear in nature. The scope of this paper is to compare the normal engineering methods of including the effects of nonlinear damping to more exact methods of solution so that the range of applicability of the normal methods may be known and the limitations of linear analysis more fully understood.

FATIGUE

(Also see No. 2202)

83-2285

The Determination of the Failure of Machine Elements during Operation by Means of Galvanic Copper Plating (Untersuchung des Ermüdungszustandes von Maschinenelementen während des Betriebes mit Hilfe der Galvanischen Verkupferung)

S.G. Kerimov and O.A. Mamed-Zade
Aserbaidshanische Hochschule f. Erdöl und Chemie „M. Asisbekow," UdSSR, Baku, Maschinenbautechnik, 32 (4), pp 180-182 (Apr 1983) 6 figs, 1 table, 5 refs
(In German)

Key Words: Fatigue life, Machinery components

A galvanic copper plating method is presented, which can be used for the determination of fatigue of machine elements during operation. The applicability and accuracy of the method is illustrated by an example.

83-2286

Fatigue Crack Propagation in an HSLA Steel (MF-80) in Air and in Salt Water

S.J. Gill and T.W. Crooker
Naval Res. Lab., Washington, DC, Rept. No. NRL-MR-5048, 25 pp (Apr 1983)
AD-A127 423

Key Words: Fatigue life, Crack propagation

Fatigue crack propagation was studied in MF-80 HSLA steel in ambient room air and in 3.5 percent NaCl salt water. Region-II fatigue crack growth rate (da/dN) data were obtained at two load ratios.

83-2287

Growth of Ring-shaped Edge Cracks under Reversed Torsional Fatigue

T. Matake, Y. Imai, and T. Takase
Dept. of Mech. Engrg., Nagasaki Univ., Bunkyo-machi, Nagasaki, 852, Japan, Bull. JSME, 26 (215), pp 692-699 (May 1983) 17 figs, 11 refs

Key Words: Fatigue life, Crack propagation

Mode III fatigue crack growth was studied using cylindrical specimens with ring-shaped edge cracks under reversed torsion. Cracks grew locally in Mode I making small branches but their macroscopic growth direction was perpendicular to the specimen axis. The crack depth was successively estimated by the compliance calibration method and the growth rate of torsional cracks was related to the applied stress intensity factor range ΔK_{III}.

ELASTICITY AND PLASTICITY

83-2288

Dynamic Young's Moduli of Some Commercially Available Polyurethanes

R.N. Capps
Naval Res. Lab., Underwater Sound Reference Detachment, P.O. Box 8337, Orlando, FL 32856, J. Acoust. Soc. Amer., 73 (6), pp 2000-2005 (June 1983) 15 figs, 9 refs

Key Words: Elastomers, Modulus of elasticity, Resonance tests, Viscoelastic properties, Wave propagation

The Young's modulus and loss tangent were measured in air for a number of commercially available polyurethanes. A resonance technique was used for measurements over the approximate frequency range 10^2 to 10^4 Hz and the approximate temperature range 40° to −5°C. Master curves and Williams-Landel-Ferry shift constants were determined for the materials tested. The automated data acquisition system used is described. The experimental procedure was found to be a reliable method for determining the viscoelastic constants for extensional wave propagation in elastomeric materials.

83-2289

Frictional Slip Between a Layer and a Substrate Due to a Periodic Tangential Surface Force

M. Comninou and J.R. Barber
Univ. of Michigan, Ann Arbor, MI, 48109, Intl. J. Solids Struc., 19 (6), pp 533-539 (1983) 7 figs, 9 refs

Key Words: Stick-slip response, Fretting corrosion

A solution is given for the problem of an elastic layer pressed against an elastic half-plane and subjected to a tangential

force varying periodically in time. A loading cycle which initially causes localized slip is followed through unloading and reloading. A limiting load is established below which the steady state of the interface does not involve slip.

83-2290

Further Studies on Dynamic Crack Branching

M. Ramulu, A.S. Kobayashi, B.S.-J. Kang, and D.B. Barker

Dept. of Mech. Engrg., Univ. of Washington, Seattle, WA, Rept. No. UWA/DME/TR-82/46, 26 pp (Mar 1983)

AD-A126 444

Key Words: Crack propagation

Crack branching represents one extreme of the large range of dynamic crack propagation behaviors and has been the subject of numerous theoretical and experimental investigations. A crack curving and a branching criteria based on the directional stability of a propagating crack was recently derived.

WAVE PROPAGATION

(Also see Nos. 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2258, 2303)

83-2291

On the Structure of the Directivity for Scattering by a Rigid Strip

W. Poppe

Max-Planck-Institut f. Strömungsforschung, Böttingerstrasse 4-8, D-3400 Göttingen, West Germany, Acustica, 52 (5), pp 273-278 (Apr 1983) 4 figs, 6 refs

Key Words: Wave diffraction

Recent studies on scattering problems lead to the result that for scattering of a plane wave by a rigid strip the directivity, which is a function of the angle of incidence and the angle of observation, may be expressed in terms of a function of one variable only. This feature is not obviously shown by the classical representations of the directivity. In this paper the relation between the long-known solutions and the recent results is investigated.

83-2292

The Determination of the Elastodynamic Fields of an Ellipsoidal Inhomogeneity

L.S. Fu and T. Mura

Dept. of Engrg. Mechanics, Ohio State Univ., Columbus, OH 43210, J. Appl. Mech., Trans. ASME, 50 (2), pp 390-396 (June 1983) 8 figs, 21 refs

Key Words: Wave propagation

Elastic fields of a single ellipsoidal inhomogeneity embedded in an infinite elastic matrix subjected to plane time-harmonic waves are studied by employing the concept of eigenstrain and the extended version of Eshelby's method of equivalent inclusion. Using the dynamic version of the Betti-Rayleigh reciprocal theorem, an integral representation of the displacement field, due to the presence of inhomogeneity, is given in terms of the eigenstrains.

83-2293

Generalized Reaction Principles and Reciprocity Theorems for the Wave Equations, and the Relationship Between the Time-Advanced and Time-Retarded Fields

N.N. Bojarski

J. Acoust. Soc. Amer., 74 (1), pp 281-285 (July 1983) 5 refs

Key Words: Wave equation, Reciprocity principle

Generalized reaction principles and generalized reciprocity theorems for the scalar and vector wave equations are derived. It is shown that the reaction principles of Rumsey and the reciprocity theorems of Welsh are special cases of these generalized reaction principles and generalized reciprocity theorems. The generalized reciprocity theorems are cast in terms of the time-retarded fields only, as well as in terms of the time-retarded and time-advanced fields.

83-2294

Propagation of Love Waves on a Cylindrical Earth Model

A. Chattopadhyay and N.P. Mahata

Dept. of Physics and Mathematics, Indian School of Mines, Dhanbad-826004, India, J. Acoust. Soc. Amer., 74 (1), pp 286-293 (July 1983) 5 figs, 14 refs

Key Words: Elastic waves, Wave propagation, Earth models

The effects of different radial inhomogeneities on the propagation of Love waves over a circular cylindrical surface are discussed and distinctly marked on the dispersion curves. The phase velocity due to an assumed type of inhomogeneity becomes larger or smaller than that for a homogeneous layer according to whether the value of kh is more or less than 0.625. Using the above deduction and the perturbation technique, the modified dispersion equation of Love waves in a nonhomogeneous crustal layer with corrugated surface are obtained.

83-2295
Antiplane Strain Harmonic Waves in Infinite, Elastic, Periodically Triple-Layered Media

K. Karim-Panahi
Div. of Applied Mechanics, Stanford Univ., Stanford, CA 94301, J. Acoust. Soc. Amer., 74 (1), pp 314-319 (July 1983) 9 figs, 11 refs

Key Words: Layered materials, Wave propagation, Wave attenuation, Harmonic waves

Propagation of horizontally polarized shear waves in periodically triple-layered, elastic medium is studied by using Floquet's theorem. The dispersion relation is characterized. The propagation and attenuation of harmonic waves inside and outside the Brillouin zones are identified. Variation of the spectrum following the modification of the comparative mechanical properties of the three layers is also examined.

EXPERIMENTATION

MEASUREMENT AND ANALYSIS

(Also see Nos. 2268, 2314, 2315)

83-2296
Greater Accuracy in Modal Analysis

C. Van Karsen
Structural/Kinematics, Warren, MI, Mach. Des., 55 (13), pp 105-108 (June 9, 1983) 5 figs

Key Words: Modal analysis

An approach to large structure modal analysis is described which evenly excites the entire structure with two shakers driven by two independent random signals. Special software routines handle the vibration data in the Fourier analyzer system. In addition to conventional modal analysis, a data-management program called Dual Shaker organizes and keeps track of the exciter and response data. Also, software called the Enhanced Measurement for Experimental Testing (EMET) expands the data capacity of the analzyer.

83-2297
Modal Density - A Limiting Factor in Analysis

G.F. Lang
Fox Technology Corporation, Westwood, NJ, S/V, Sound Vib., 17 (3), pp 20-22 (Mar 1983) 10 figs

Key Words: Modal analysis, Parameter identification techniques

Modal density describes the frequency proximity of adjacent modes, and thus their susceptibility to precise measurement. At low density an experimental modal analysis is limited by the frequency resolution of the analysis system. At high density, a structure's dynamics defy modal decomposition by signal processing techniques, alone; zoom processing proves unable to separate overlapping modal bandwidths and spatial decomposition must be employed. Between these extremes, the analysis is limited by the sophistication and precision of the modal parameter identification algorithms employed.

83-2298
Selective Modal Analysis in Power Systems. Final Report

G.C. Verghese, I.J. Perez-Arriaga, F.C. Schweppe, and K.W.K. Tsai
Electric Power Systems Engrg. Lab., Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. EPRI-EL-2830, 98 pp (Jan 1983)
DE83901586

Key Words: Modal analysis, Dynamic stability

A promising new framework for analyzing and reducing the large, linear, time-invariant dynamic models used to study dynamic stability in power systems is investigated. The framework is termed Selective Modal Analysis or SMA, and goes beyond traditional modal analysis methods in ways that appear crucial to successful practical use of modal methods in both on-line and off-line studies. Comparisons with existing approaches to the dynamic stability problem are made, and the distinctive features of SMA are brought out.

83-2299

Digital Correlation of Spread-Spectrum Signals via Frequency Domain Processing

J.A. Carretto, Jr.

School of Engrg., Air Force Inst. of Tech., Wright-Patterson AFB, OH, Rept. No. AFIT/GE/EE/82S-15, 70 pp (July 1982)
AD-A127 434

Key Words: Frequency domain method

Background information on the theory behind processing spread-spectrum synchronization data in the frequency domain is presented. The derivation shows that the time domain pseudo-noise sequence offset is represented in the frequency domain by frequency modulation on a known carrier wave. Following the background development is a detailed description of the analog hardware used to implement the frequency domain processing techniques. A proposed method of digitally extracting the synchronization data by Fourier transforming the analog output signal is presented.

83-2300

A Comparison of Field Data Collection Techniques for Use in the Two Surface Method of Sound Power Level Determination

K.R. Baki and R.A. Putnam

Gilbert/Commonwealth, Jackson, MI, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 355-360, 8 figs, 11 refs

Key Words: Two surface method, Sound power levels, Measurement techniques, Noise source identification

A method to determine sound power levels in situ in the presence of high background noise is the subject of a forthcoming ASTM standard. The proposed test procedure, using a form of the two surface method, carefully defines most data collection parameters, but allows for considerable flexibility in the size of surveyed areas. This paper compares the results of two unique approaches to this test variable. Differences in computer generated sound power calculations for four high speed manufacturing machines are presented using both a gross sweep area, and a smaller, more detailed area methodology.

83-2301

Digital Techniques for Enhancing and Processing Dynamic Stress-Analysis Data

J.S.W. Taylor

Univ. of Surrey, Dept. of Mech. Engrg., Surrey, UK, Exptl. Techniques, 7 (6), pp 31-35 (June 1983) 6 figs, 4 refs

Key Words: Dynamic tests, Testing techniques, Digital techniques, Time domain method

A time-domain approach for processing of transducer signals and the implementation of the digital processing techniques is described, which leads to a very effective system for the enhancement and analysis of dynamic-mechanical test data.

83-2302

An Extension of Parseval's Theorem and Its Use in Calculating Transient Energy in the Frequency Domain

S.S. Kelkar, L.L. Grigsby, and J. Langsner

Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24601, IEEE Trans., Indus. Electronics, IE-30 (1), pp 42-45 (Feb 1983) 3 figs, 4 refs

Key Words: Transient response, Frequency domain method

An analysis is presented which leads to an equation useful for calculating energy in the frequency domain. The equation is seen to be an extension of Parseval's theorem and is very useful for calculating the energy content of pulses that are difficult to treat in the time domain. An algorithm based on the equation has been programmed in Fortran.

83-2303

Dynamic Applications of Piezoelectric Crystals. Part III: Experimental Studies

M.C. Dökmeci

Istanbul Technical Univ., P.K. 9, Istanbul, Turkey, Shock Vib. Dig., 15 (5), pp 11-22 (May 1983) 173 refs

Key Words: Structural members, Piezoelectricity, Wave propagation, Acoustic waves, Reviews

This paper presents a review of current open literature pertaining to the dynamic applications of piezoelectric crystals. Representative theoretical and experimental papers cover waves and vibrations in piezoelectric one-dimensional and two-dimensional structural elements. New trends of research are pointed out for future applications of piezoelectric crystals.

83-2304

Mechanical Impedance Gauge Based on Measurement of Strains on an Impacted Rod

L. Lagerkvist and K.G. Sundin
Dept. of Mech. Engrg., Univ. of Lulea, S-951 87 Lulea, Sweden, J. Sound Vib., 88 (2), pp 225-231 (May 22, 1983) 5 figs, 7 refs

Key Words: Mechanical impedance, Measuring instruments

An impedance gauge based on measurement of strains at two cross-sections of a slender rod is studied. The gauge rod is in contact with the object at one end while it is impacted at the other end. The impedance is evaluated from the two strain signals by means of a two-channel FFT-analyzer and a desk-top computer. Gauge prototypes with cylindrical and conical geometries are tested in the frequency range 50 Hz to 5 kHz for cylindrical objects with known theoretical point impedances.

83-2305

Vibration Analysis of Piezoceramic Bimorphic Cylindrical Shell in the Two Dimensional Coordinate System by Means of Finite Element Method

R. Barauskas and L. Limanauskas
Kaunas Politechnical Institute, Kaunas, Lithuanian SSR, Vibrotechnika, 4 (38), pp 93-101 (1981) 6 figs, 2 tables, 8 refs
(In Russian)

Key Words: Transducers, Piezoceramics, Vibration analysis, Finite element technique

The vibrations of piezoceramic transducer, represented by a cylindrical shell, are analyzed. The wall of the shell is bimorfic: the exterior layer of it is piezoceramic, polarized in the direction of the radius; the interior is metallic. Because of the differences in length and radius of the shell, calculations are performed in two dimensions. Natural frequencies, modes of vibration, and amplitudes in the radial and tangential directions under harmonic electric excitation are determined by the finite element method. The dependencies of natural frequencies and the amplitudes of vibrations on the thickness of bimorphic layers are presented.

83-2306

Ground Couplings and Measurement Frequency Ranges of Vibration Transducers

S. Omata
College of Engrg., Nihon Univ., Tokusada, Koriyama, Fukushimaken 963, Japan, J. Acoust. Soc. Amer., 73 (6), pp 2187-2192 (June 1983) 7 figs, 2 tables, 13 refs

Key Words: Vibration transducers, Ground vibration

This paper examines characteristics of frequency response of a vibration transducer placed on the ground. Optimum relationships between the base area and the weight of the transducer for decreasing the effect of ground coupling under all conditions are provided.

83-2307

Effect of Mounting Constraints on the Response of Piezoelectric Disks

D.B. Bogy and R.T-K. Su
Dept. of Mech. Engrg., Univ. of California, Berkeley, CA 94720, J. Acoust. Soc. Amer., 73 (6), pp 2210-2215 (June 1983) 8 figs, 9 refs

Key Words: Piezoelectric transducers

An experimental investigation was conducted to determine the effects of different edge conditions and face mount backing conditions on the electrical response of strongly coupled piezoelectric disks with electroded faces on which spatially nonuniform forces are applied by a pencil lead breaking mechanism. Various mounting schemes were employed to simulate traction-free, simply supported, and fixed edge conditions. Experiments were also conducted on a commercially available transducer in various stages of dismantlement.

83-2308

Vibration Analysis of Asymmetric Bimorfic Piezoceramic Transducers by the Finite Element Technique

R. Barauskas and L. Limanauskas
Kaunas Politechnical Institute, Kaunas, Lithuanian SSR, Vibrotechnika, 4 (38), pp 85-92 (1981) 1 fig, 2 tables, 6 refs
(In Russian)

Key Words: Transducers, Vibration analysis, Piezoceramics, Finite element technique

The finite element method is used for the vibration analysis of bimorfic asymmetric piezoceramic transducers, consisting

of piezoceramic and metallic layers fixed to one another. Stiffness and mass matrices of beam type finite element are obtained, taking into account transverse and longitudinal displacements. The results of numerical analysis are presented.

83-2309

Investigation of Continuously Traversing Microphone System for Mode Measurement

D.E. Cicon, T.G. Sofrin, and D.C. Mathews

Pratt and Whitney Aircraft Group, East Hartford, CT, Rept. No. NASA-CR-168040, 135 pp (Nov 1982)

N83-19575

Key Words: Acoustic measurement, Measurement techniques, Modal analysis, Data processing, Ducts, Fans

The continuously traversing microphone system consists of a data acquisition and processing method for obtaining the modal coefficients of the discrete, coherent acoustic field in a fan inlet duct. The system would be used in fan rigs or full scale engine installations where present measurement methods, because of the excessive number of microphones and long test times required, are not feasible. The purpose of the investigation reported here was to develop a method for defining modal structure by means of a continuously traversing microphone system and to perform an evaluation of the method, based upon analytical studies and computer simulated tests.

83-2310

Experimental Determination of Vibration Parameters Required in the Statistical Energy Analysis Method

B.L. Clarkson and R.J. Pope

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton, UK, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (3), pp 337-344 (July 1983) 10 figs, 8 refs

Key Words: Dynamic tests, Testing techniques, Modal densities

In the high frequency range of vibration the statistical energy method provides one of the most convenient ways of estimating vibration levels in structural components. The dynamic characteristics of the structure are described in terms of the modal densities, dissipation loss factors and coupling loss factors of the component parts. Theoretical and semi-empirical results are available for some typical components. This paper describes the development of indirect methods for the experimental determination of these three parameters.

83-2311

Noise/Vibration Control by Structural Modification - When and What to Consider

C.I. Holmer and D.T. Lilley

E-A-R Division of Cabot Corp., 7911 Zionsville Rd., Indianapolis, IN 46268, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 123-132, 5 figs, 13 refs

Key Words: Noise reduction, Vibration control, Structural modification techniques

This paper is intended as an introduction to a group of papers dealing with structural modification as a mechanism for noise control at the source. The source class dealt with consists of machinery which generates vibration that is transformed at machine surfaces to radiated sound, excluding sources which generate noise via direct radiation from turbulent flow.

83-2312

Application of the Eigenvalue Modification Technique to Nonproportionally Damped Structures

G. Prater, Jr. and R. Singh

The Ohio State Univ., 206 W. 18th Ave., Columbus, OH 43210, NOISE-CON 83, Quieting the Noise Source, Proc. of Natl. Conf. on Noise Control Engrg., Massachusetts Inst. Tech., Cambridge, MA, Mar 21-23, 1983, pp 133-142, 3 figs, 4 refs

Key Words: Structural modification techniques, Damped structures

A summary of the advantages and disadvantages of a commonly used method for the modification of discrete dynamic systems -- the eigenvalue modification technique (EMT) -- is presented. The EMT uses modal data from the original system to simplify computation of the natural frequencies and modes of a modified system. Its use generally results in significantly lower computation costs, especially for complicated systems.

DYNAMIC TESTS

(Also see No. 2301)

83-2313

Effects of Specimen Resonances on Acoustic-Ultrasonic Testing

J.H. Williams, Jr., E.B.Kahn, and S.S. Lee

Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. NASA-CR-3679, 36 pp (Mar 1983)

N83-21373

Key Words: Ultrasonic techniques, Testing techniques, Resonant frequencies

The effects of specimen resonances on acoustic ultrasonic nondestructive testing were investigated. Selected resonant frequencies and the corresponding normal mode nodal patterns of the aluminum block are measured up to 75.64 kHz. Prominent peaks in the pencil lead fracture and sphere impact spectra from the two transducer locations corresponded exactly to resonant frequencies of the block.

83-2314

Modal Testing of a Rotating Wind Turbine

T.G. Carne and A.R. Nord

Sandia Natl. Lab., Albuquerque, NM, Rept. No. SAND-82-0631, 19 pp (Nov 1982)

DE83003630

Key Words: Modal tests, Turbines, Wind turbines

A testing technique has been developed to measure the modes of vibration of a rotating vertical-axis wind turbine. This technique has been applied to the Sandia two-meter turbine, where the changes in individual modal frequencies as a function of the rotational speed, have been tracked from 0 rpm (parked) to 600 rpm. During rotational testing, the structural response was measured using a combination of strain gages and accelerometers, passing the signals through slip rings. In addition to calculating the real modes of the parked turbine, the modes of the rotating turbine were also determined at several rotational speeds.

83-2315

Some Application of the Transfer Function Technique to the Modal Survey Tests

National Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-736, ISSN-0389-4010, 16 pp (1982)

N83-19122

(In Japanese)

Key Words: Modal tests, Transfer functions

Applications of the transfer function method to structural dynamic modal tests are presented. Three test structures; i.e., a carbon-fiber reinforced-plastic box beam, an aircraft structural model, and the Fuji FA-200X are used. The tests are conducted by the conventional sine dwell resonance method as well as the one point excitation transfer function method.

83-2316

Characterization of Conservatism in Mechanical Shock Testing of Structures

T.J. Baca

Ph.D. Thesis, Stanford Univ., 193 pp (1983)

DA8307129

Key Words: Shock tests, Testing techniques

The objective of this research is to characterize field and test environments in a way that will allow quantitative statements to be made about the conservatism of a shock test. Alternative characterizations of shock transients are introduced which compensate for the limitations of absolute acceleration shock spectra in representing shock environments. A method of characterizing both field and laboratory shock environments is developed which can be used for any type of shock characterization to account for the variability in the description of the environments. Conservatism between the field and laboratory shock environment is then quantified in terms of the index of conservatism.

83-2317

Piezoelectric Shaker for Simulating Earthquakes

J.G. Canclini and J.M. Henderson

Air Logistics Command, Kelly AFB, TX 78241, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 11-16 (Jan 1983) 11 figs, 7 refs

Key Words: Shakers, Piezoelectric shakers, Earthquake simulation

A centrifuge can theoretically simulate gravity-induced stress on earthen structures at a reduced geometric scale through centrifuge loading. These scaling laws show the usefulness of

the centrifuge to test large structures of a size that cannot be tested practically in any other fashion. Seven possible shaker designs were considered. The paper presents a description of the piezoelectric shaker chosen and its development for a 5-g ton capacity centrifuge.

83-2318

Vibration and Aeroelastic Facility

P.G. Bolds

Air Force Wright Aeronautical Labs., Wright-Patterson AFB, OH, Rept. No. AFWAL-TR-82-3054, 100 pp (Dec 1982)
AD-A126 317

Key Words: Vibration tests, Test facilities

The vibration and aeroelastic facility of the Air Force Wright Aeronautical Laboratories is used for recording and analyzing dynamics data. New instrumentation systems have made possible a significant increase in the quantity of measurements which can be acquired to define the dynamics environment in various aircraft, missile, and ground support equipment. To reduce the large quantities of data to a usable form, processing techniques based upon the use of spectrum analyzers and minicomputers are employed. These techniques are described and methods are illustrated for presenting statistical quantities defining the spectral composition of dynamics environments.

DIAGNOSTICS

83-2319

Diagnosis of Fracture Damage in Simple Structures: A Modal Method

F.J. Ju, M. Akgun, T.L. Paez, and E.T. Wong

Bureau of Engrg. Res., Univ. of New Mexico, Albuquerque, NM, Rept. No. CE-62(82)AFOSR-993-1, AFOSR-TR-83-0049, 58 pp (Oct 1982)
AD-A125 714

Key Words: Diagnostic techniques, Crack detection, Modal analysis

A method to locate fracture damage in a structure and to estimate the intensity of the damage is investigated.

83-2320

Acoustic-Emission Linear-Pulse Holography

H.D. Collins, D.K. Lemon, and L.J. Busse

Battelle Pacific Northwest Labs., Richland, WA, Rept. No. PNL-SA-10523, CONF-820765-1, 16 pp (June 1982) (Intl. Symp. on Acoustical Imaging, London, UK, July 19, 1982)
DE83003476

Key Words: Diagnostic techniques, Nondestructive tests, Crack propagation, Acoustic emission, Holographic techniques

This paper describes acoustic emission linear pulse holography which combines the advantages of linear imaging and acoustic emission into a single NDE inspection system. This unique system produces a chronological linear holographic image of a flaw by utilizing the acoustic energy emitted during crack growth.

83-2321

Abnormal Wear of Gear Couplings – A Case Study

T. Chander and S. Biswas

Bharat Heavy Electricals Ltd., Hyderabad - 500 593, India, Tribology Intl., 16 (3), pp 141-146 (June 1983) 15 figs, 3 tables, 8 refs

Key Words: Couplings, Flexible couplings, Gears, Diagnostic techniques

A number of failures which occurred in the gear coupling transmitting the torque from a steam turbine (rotating at 7500 r/min) to a 1.5 MW generator through a 1:5 reduction gear box are studied.

83-2322

Research to Develop and Evaluate Advanced Eddy Current Sensors for Detecting Small Flaws in Metallic Aerospace Components

J.M. Prince and B.A. Auld

Battelle Pacific Northwest Labs., Richland, WA, Rept. No. AFWAL-TR-82-4155, 101 pp (Dec 1982)
AD-A125 873

Key Words: Diagnostic instrumentation, Eddy current probes, Ferromagnetic resonance

The purpose of this program was to develop a reproducible, highly sensitive novel eddy current probe applying the

technique of ferromagnetic resonance (FMR). The method developed must be suited to inspect test objects where access may be limited; for example, bolt holes of turbine engine disks. This program studied the FMR probe in both its passive and active modes.

BALANCING

(Also see No. 2326)

83-2323

Balancing of Flexible Rotors by the Complex Modal Method

S. Saito and T. Azuma
Res. Inst., Ishikawajima-Harima Heavy Industries Co., Ltd., 3-1-15, Toyosu, Koto-ku, Tokyo, Japan,
J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 94-99 (Jan 1983) 10 figs, 4 tables, 22 refs

Key Words: Balancing techniques, Flexible rotors, Rotors, Fluid-film bearings

A new calculation method of the modal unbalance response for general flexible rotors in fluid film bearings is developed by introducing the concept of modal exciting force vector into the usual complex modal method. The physical meaning of the damping ratio at a critical speed is discussed. Application of this method, correction weights determined in only one trial operation, is reported, and positions to measure vibration and to correct unbalance weight are discussed on the basis of the right eigenvector and the exciting factor mode, respectively.

83-2324

A Computational Technique for Optimizing Correction Weights and Axial Location of Balance Planes of Rotating Shafts

W.D. Pilkey, J. Bailey, and P.D. Smith
Univ. of Virginia, Charlottesville, VA 22901, J. Vib. Acoust. Stress Rel. Des., Trans. ASME, 105 (1), pp 90-93 (Jan 1983) 2 figs, 2 tables, 4 refs

Key Words: Balancing techniques, Shafts, Influence coefficient method

An iterative procedure is presented for the balancing of a flexible rotor. In addition to determining optimal correction weights, the number and axial positions of the balance planes are optimized. A linear programming solution is employed using a linearized approximation of the axial variation of the influence coefficients.

83-2325

Balancing of Linkages -- an Update

G.G. Lowen, F.R. Tepper, and R.S. Berkof
Dept. of Mech. Engrg., City College of the City University of New York, NY 10031, Mech. Mach. Theory, 18 (3), pp 213-220 (1983) 158 refs

Key Words: Dynamic balancing, Balancing techniques, Linkages

Improved balancing techniques have been required more frequently as machine performance specifications have become more demanding. Following this trend, many more technical papers on the dynamic balancing of mechanisms have been published in the past few years. This recent literature on the force and moment balancing of linkages is surveyed.

MONITORING

83-2326

Vibration and Balance Problems in Fossil Plants: Industry Case Histories

N.L. Baxter
Public Service Co. of Indiana, Inc., Plainfield, IN, Rept. No. EPRI-CS-2725, 156 pp (Nov 1982)
DE83900743

Key Words: Monitoring techniques, Balancing techniques, Fossil power plants, Power plants (facilities)

The purpose of this report is to demonstrate some practical uses of vibration analysis through the presentation of actual field case histories. The case histories contained in the report include turbines, generators, fans, pump and electric motors common to the utility industry. Each case history is divided into six sections: definition of the problem, symptoms of the problem, test data and observations, corrective actions taken, final results, conclusions and recommendations.

ANALYSIS AND DESIGN

ANALYTICAL METHODS

83-2327

The Equivalence of Time Integration Method for

Dynamic Systems (Zur Äquivalenz der Zeitintegrationsverfahren für dynamische Systeme)
M. Weber
Akad. of Sci., German Dem. Rep., DDR-1199 Berlin, Z. angew. Math. Mech., 63 (3), pp 151-160 (1983) 1 table, 12 refs
(In German)

Key Words: Dynamic systems, Time integration method

This paper deals with the comparison of the most important algorithms for the direct time integration of dynamic systems. The algorithms are divided in several classes with respect to the used deduction methods.

83-2328
Dynamic Analysis of Mechanisms via Vector Network Model
K. Singhal and H.K. Kesavan
Dept. of Systems Design, Univ. of Waterloo, Waterloo, Ontario, Canada, Mech. Mach. Theory, 18 (3), pp 175-180 (1983) 3 figs, 4 refs

Key Words: Vector network model, Mechanisms, Computer-aided techniques

The vector network model has already been defined both for problems in dynamics as well as for kinematics. For the latter, the model was developed for a sequential determination of position, velocity and acceleration variables associated with mechanisms. This paper deals with the next phase of kinematic analysis; namely, the dynamic analysis of mechanisms.

83-2329
Frequency-Domain Reduction of Linear Systems Using Schwarz Approximation
T.N. Lucas and A.M. Davidson
Dept. of Mathematics and Computer Studies, Dundee College of Tech., Bell St., Dundee, UK, Intl. J. Control, 37 (5), pp 1167-1178 (May 1983) 2 figs, 4 tables, 12 refs

Key Words: Approximation methods, Frequency domain method, Linear systems

A frequency domain approach for reducing linear, time-invariant systems is presented which produces stable approximation of stable systems. The method is based upon the Schwarz canonical form and is shown to have a continued-fraction representation. A link between this method and the popular Routh approximation is also given.

83-2330
Characterization of Frequency Stability: Bias Due to the Juxtaposition of Time-Interval Measurements
P. Lesage
Laboratoire de l'Horloge Atomique, Equipe de Recherche due CNRS, Associée à l'Université Paris-Sud, 91405, Orsay, France, IEEE Trans., Instrum. Meas., IM-32 (1), pp 204-207 (Mar 1983) 5 figs, 1 table, 7 refs

Key Words: Frequency analysis

The characterization of frequency stability is usually achieved by means of numerically processed time-interval measurements. In the present paper, the bias occurring in the frequency stability measure when successive data with the same mean durations are added in order to get different sets of samples with various mean durations is studied. The effect of a dead time between the data involved in the considered algorithm is pointed out. An experimental analysis is presented which checks the theoretical results for several noise processes in different experimental conditions.

83-2331
Dynamic Analysis of Large Scale Inertia-Variant Flexible Systems
A.A.-E. Shabana
Ph.D. Thesis, Univ. of Iowa, 211 pp (1982)
DA8310084

Key Words: Transient response, Equations of motion, Variable material properties

A method employing a variable number of degrees of freedom is developed for transient dynamic analysis of mechanical systems consisting of constrained rigid and flexible bodies with large angular rotations. Gross displacement of elastic bodies is represented by superposition of small elastic displacements on large displacement of body reference frames. For each elastic body two sets of generalized coordinates are employed.

83-2332

Alternative Bond Graph Causal Patterns and Equation Formulations for Dynamic Systems

D. Karnopp
Univ. of California, Davis, CA 95616, J. Dynam. Syst., Meas. Control, Trans. ASME, 105 (5), pp 58-63 (June 1983) 6 figs, 7 refs

Key Words: Bond graph technique

Given mathematical models of components of a system, the equations for the system can be formulated in a number of distinct ways. Bond graphs provide a convenient explicit way to study the interactions among component models and the system equation formulations which follow from the various ways in which input-output causality can be assigned. Three means of causality assignment are compared: an all-integral method, an all derivative method, and a Lagrange-equation procedure. Some interesting differences among the procedures occur when fields (dependent state variables) or nonlinear junction structures (geometric nonlinearities) are present in the system model.

83-2333

Accuracy Criteria for Evaluating Supersonic Missile Aerodynamic Coefficient Predictions

R.J. Krieger and J.E. Williams
McDonnell Douglas Astronautics Co., St. Louis, MO, J. Spacecraft Rockets, 20 (4), pp 323-330 (July/Aug 1983) 6 figs, 10 tables, 11 refs

Key Words: Aerodynamic stability, Prediction techniques, Error analysis

Aerodynamic prediction methods are traditionally compared with wind-tunnel test data. However, the assessment of accuracy is left to an arbitrary interpretation. An accuracy criterion has been developed that defines the required prediction accuracy in terms of allowable errors in missile performance and missile design parameters. Equations have been selected that relate these parameters to the aerodynamic drag, stability, and control coefficients. These equations are differentiated with respect to the aerodynamic coefficients and simplified when possible.

83-2334

Preliminary Look at Control Augmented Dynamic Response of Structures

R.S. Ryan and R.E. Jewell
George C. Marshall Space Flight Ctr., NASA, Huntsville, AL, Rept. No. NASA-TM-82512, 31 pp (Feb 1983)
N83-20281

Key Words: Mass coefficients, Damping coefficients, Stiffness coefficients

The augmentation of structural characteristics, mass, damping, and stiffness through the use of control theory in lieu of structural redesign or augmentation is reported. The standard single-degree-of-freedom system was followed by a treatment of the same system using control augmentation. The system was extended to elastic structures using single and multi-sensor approaches and concludes with a brief discussion of potential application to large orbiting space structures.

83-2335

Generalized Rayleigh-Ritz Method for Structural Dynamics Problems in Conjunction with Finite Elements

J.J. Wu
Large Caliber Weapon Systems Lab., Army Armament Res. and Dev. Command, Watervliet, NY, Rept. No. ARLCB-TR-83006, 23 pp (Feb 1983)
AD-A126 481

Key Words: Rayleigh-Ritz method, Finite element technique

A solution formulation of generalized Rayleigh-Ritz method is described and applied to two initial and boundary value problems of stress waves and structural dynamics in conjunction with finite element discretization. Excellent numerical results have been obtained for wave equations associated with lateral and longitudinal vibrations and with strong discontinuities.

83-2336

Rayleigh's Contributions to Modern Vibration Analysis

G.B. Warburton
Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham NG7 2RD, J. Sound Vib., 88 (2), pp 163-173 (May 22, 1983) 1 fig, 49 refs

Key Words: Vibration analysis, Rayleigh method

Although Rayleigh performed his work on vibrations approximately one hundred years ago, his contributions with their

emphasis on energy principles, approximate methods of solution and use of physical insight to assess problems lead directly to some of the most powerful methods of vibration analysis which are in use today. His contributions and their relationship to modern analytical methods are outlined and illustrated by simple examples.

PARAMETER IDENTIFICATION

(Also see No. 2198)

83-2337

Parameter Identification and Control of Distributed-Parameter Systems

H. Baruh

Ph.D. Thesis, Virginia Polytechnic Inst. and State Univ., 125 pp (1981)

DA8210374

Key Words: Parameter identification technique, Continuous parameter method

Two methods, one for the identification and one for the control implementation of distributed-parameter systems, are presented. The methods are designed to identify and control the actual distributed system, without resorting to discretization.

83-2338

A Study on Parameter Determination Method of Large-Scale and Complex Dynamic Systems with Judgment Functions (No. 1) - Theory

O. Furukawa, H. Ikeshoji, and S. Iida

Kubota Ltd., Sakai, Japan, J. Dynam. Syst., Meas. Control, Trans. ASME, 105 (5), pp 64-69 (June 1983) 5 figs, 19 refs

Key Words: Parameter identification technique, Judgment functions

In the design of large-scale and complex mechanical systems, determination of design parameters is a very difficult problem. This study deals with parameter satisfaction problems of large-scale, complex, and dynamic systems with judgment functions. In order to solve these problems, a new method is proposed which sequentially exchanges the original mathematical model to an analyzable approximate model by means of the identification method.

83-2339

A Study on Parameter Determination Method of Large-Scale and Complex Dynamic Systems with Judgment Functions (No. 2) - Applications

O. Furukawa, H. Hiroyasu, and S. Iida

Kubota Ltd., Sakai, Japan, J. Dynam. Syst., Meas. Control, Trans. ASME, 105 (5), pp 70-76 (June 1983) 11 figs, 1 table, 14 refs

Key Words: Parameter identification technique, Judgment functions, Diesel engines

This paper deals with the parameter satisfaction problems of a gas exchanging system which are important from the standpoint of quality design. Report No. 1 proposed a method to solve the parameter satisfaction problems of such systems. In this paper, the method is applied and a parameter improvement system which can improve many parameters efficiently without enormous calculations of partial derivatives is constructed.

83-2340

Mode Identification of Bilinear Systems

C.B. Smith, B. Kuszta, and J.E. Bailey

Dept. of Chemical Engrg., Univ. of Houston, Houston, TX 77004, Intl. J. Control, 37 (5), pp 943-957 (May 1983) 5 figs, 7 refs

Key Words: Parameter identification technique

A method is presented for the identification of the eigenvalues of systems characterized by bilinear differential equation models. The identification procedure is based on the existence of a zero harmonic, or DC shift, in the output of nonlinear systems perturbed by a periodic input.

83-2341

Parameter Estimation for the Fast and Slow Subsystems of a Process Operating in Coupled Singularly Perturbed Form

M.J. Cook

Ph.D. Thesis, Michigan State Univ., 144 pp (1982) DA8308916

Key Words: Parameter identification techniques

The input and output of a deterministic singularly perturbed system, operating in coupled form, are observed over a finite

time-interval. The problem under consideration is to determine the system parameters of the decoupled subsystems from these measurements. The nature and formulation of the singularly perturbed system are examined along with the fundamentals of systems identification. A finite time-interval identification method is investigated which utilizes a filter to annihilate the initial condition response, and models disturbances as solutions to a homogeneous differential equation. The adaptation of this method is applied to the singularly perturbed problem, and a unique procedure for its implementation is presented via a heuristic study of linear time invariant systems.

DESIGN TECHNIQUES

83-2342

Minimum Cost Design for Noise Insulation in Building Construction

F.F. Rudder and S.F. Weber

U.S. Dept. of Commerce, Natl. Bureau of Standards, Washington, DC 20234, Noise Control Engrg., 20 (3), pp 104-121 (May/June 1983) 9 figs, 3 tables, 24 refs

Key Words: Design techniques, Noise reduction

A method is described for estimating the construction cost of building components designed to achieve a specified level of noise insulation. The method also determines the noise insulation value of each component of a multi-component wall, such that the wall achieves a design level of noise insulation at the minimum construction cost. Curves of minimum construction cost as a function of design noise insulation are easily generated using the method.

COMPUTER PROGRAMS

(Also see No. 2190, 2193)

83-2343

DYNA3D User's Manual (Nonlinear Dynamic Analysis of Solids in Three Dimensions)

J.O. Hallquist

Lawrence Livermore Natl. Lab., CA, Rept. No. UCID-19592, 109 pp (Nov 1982)
DE83004058

Key Words: Computer programs, Nonlinear theories, Three dimensional problems, Finite element technique

This report provides an updated user's manual for DYNA3D, an explicit three-dimensional finite-element code for analyzing the large-deformation dynamic response of inelastic solids. DYNA3D contains fifteen material models and nine equations of state to cover a wide range of material behavior.

83-2344

Computer Programs for Estimation of the Flutter and Divergence Boundaries from Random Responses at a Subcritical Range

Y. Ando and Y. Matsuzaki

Natl. Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-737T, ISSN-0389-4010, 66 pp (Sept 1982)
N83-19498

Key Words: Flutter, Random response, Aeroelasticity

A set of computer programs for a method of estimation of the vibration characteristics and boundaries for flutter and divergence of an aeroelastic system subjected to stationary random noises is described. The programs listed are those for the calculations of the auto-covariance function of a time series and Jury's stability parameters of the characteristic equations of fourth and eight orders, and those for the estimation of the stability boundary, frequency and damping ratio of the system.

83-2345

GEMINI -- An Efficient Computer Program for Three Dimensional Linear Static and Seismic Structural Analysis

R.C. Murray

Ph.D. Thesis, Univ. of California, Davis, CA, 351 pp (1982)
DA8311926

Key Words: Computer programs, Seismic analysis, Structural members, Finite element technique, Dynamic structural analysis

GEMINI is a computer program for the calculation of static and dynamic response of linear elastic structures by the finite element method. Requests for extended capability, advances in element technology, and major algorithmic improvements in solution methodology have lead to the need, creation, and development of this program. GEMINI is written in standard FORTRAN with a modular format to allow new elements to be inserted as well as allowing equation solvers, eigenvalue routines, and modal analysis techniques to be implemented and evaluated. GEMINI is compatible with the CDC7600 and the CRAY-1 computers.

83-2346

MIDSY and ADAMS Computer Programs for Design Orientated Modeling and Identification of Linear and Nonlinear Multibody Systems (Programmsysteme MIDSY and ADAMS zum strukturorientierten Modellieren und Identifizieren von linearen und nichtlinearen Mehrkorpersystemen)

Konstruktion, 35 (6), p 246 (June 1983) 2 figs
(In German)

Key Words: Computer programs, Design techniques, Motor vehicles

The capabilities of MIDSY and ADAMS computer programs are summarized. They enable a designer, even without a thorough knowledge of vibration theory, to model, simulate, and optimize the dynamic behavior of his design (multibody system). The results of the simulation are a time- or frequency-dependent (FFT) representation of deflection, velocity and acceleration. They also show the excitation and deformation of elastic transfer elements of all the components of the system. The programs are applicable in automotive industry.

83-2347

FLUTTER: A Finite Element Program for Aerodynamic Instability Analysis of General Shells of Revolution with Thermal Prestress

D.J. Fallon and E.A. Thornton
Old Dominion Univ., Norfolk, VA, Rept. No. NASA-CR-170013, 18 pp (Mar 1983)
N83-19756

Key Words: Computer programs, Flutter, Shells of revolution

Documentation for the computer program FLUTTER is presented. The theory of aerodynamic instability with thermal prestress is discussed. Theoretical aspects of the finite element matrices required in the aerodynamic instability analysis are also discussed. General organization of the computer program is explained, and instructions are presented for the execution of the program.

83-2348

Computation of Acoustic Surface Pressure Using Boundary Integral Equations

H.R. Hall
Ph.D. Thesis, Univ. of Houston, 157 pp (1982)
DA8310662

Key Words: Computer programs, Sound pressures, Vibrating structures

This thesis describes the development and applications of a FORTRAN program for obtaining an estimate of the acoustic pressure on a closed surface vibrating steadily at a single frequency. The algorithm is based on a boundary integral equation for the pressure on the surface. The inputs required by the program are the surface geometry and motion.

83-2349

User's Guide to Producing Coherency-Based Equivalents for Transient-Stability Studies

J.V. Mitsche
Consumers Power Co., Jackson, MI, Rept. No. EPRI-EL-2778-CCM, 240 pp (Dec 1982)
DE83901140

Key Words: Computer programs, Dynamic stability

This report is the user's guide for a computer program called DYNEQ3. This program reduces a large-scale system model to a small dynamic equivalent model for use in transient stability studies. It is dimensioned large enough to model the entire eastern US interconnected system. Classical transient stability models are used.

83-2350

New Numerical Method for the Transient Gas-Dynamic Code EVENT

P.K. Tang
Los Alamos Natl. Lab., NM, Rept. No. LA-9594-MS, 21 pp (Dec 1982)
DE83007120

Key Words: Computer programs, Numerical analysis

A new numerical method to solve a system of algebraic equations for severe gas-dynamic transient problems is described. This technique involves the simultaneous consideration of both mass and energy balance at each nodal point, which should improve the convergence. A sample calculation is included.

GENERAL TOPICS

CRITERIA, STANDARDS, AND SPECIFICATIONS

83-2351
Economic Effects of Noise Abatement Regulations on the Helicopter Industry
A.N. Conner
Naval Postgraduate School, Monterey, CA, 66 pp (Dec 1982)
AD-A127 331

Key Words: Helicopters, Noise reduction, Regulations

The economic effects of noise abatement regulations on the helicopter industry are discussed. Increased manufacturing and operating costs from noise abatement regulations on Sikorsky's S-76 helicopter are estimated. The effects on consumer utilization are also discussed. An appendix compares independent research studies that used weight estimating relationships and cost estimating relationships to estimate manufacturing costs of the helicopter by subsystem.

83-2352
Numerical Simulation of Transonic Flutter of a Supercritical Wing
K. Isogai and K. Suetsugu
National Aerospace Lab., Tokyo, Japan, Rept. No. NAL-TR-726T, ISSN-0389-4010, 34 pp (Aug 1982)
N83-18743

Key Words: Aircraft wings, Flutter, Numerical methods, Simulation

The time marching three-dimensional unsteady transonic full potential code USTF3 is applied to the prediction of the flutter boundary of a supercritical wing for which reliable experimental data exist. The governing flow equation and the structural equations are integrated simultaneously to obtain the time dependent aeroelastic response of the wing.

BIBLIOGRAPHIES
(Also see Nos. 2161, 2256)

83-2353
Earthquake Engineering: Buildings, Bridges, Dams, and Related Structures. September 1980 - February 1983 (Citations from the NTIS Data Base)
NTIS, Springfield, VA, 316 pp (Apr 1983)
PB83-805184

Key Words: Bibliographies, Seismic design, Bridges, Buildings, Dams

Seismic phenomena relative to buildings, bridges, dams, and other structures are investigated. Damage assessment is made and design inadequacies are revealed. Suggestions for structural improvements for dynamic response are presented. Abstracts on site selection and earthquake-proofing for atomic power plants are included.

83-2354
Vibration in Turbomachinery: A Bibliography of Research Reports (1966 - 1981)
P.M.E. Percival
Dept. of Engrg., Cambridge Univ., UK, Rept. No. CUED/A-TURBO/TR-109-1982, 26 pp (Apr 1982)
PB83-187369

Key Words: Turbomachinery, Aerodynamic loads, Vibration response, Bibliographies

This report is mainly concerned with papers which have been written in English or which are available in translations. The first part of the bibliography is an alphabetical list of authors, with a separate list of Russian authors. This is followed by a list of authors and titles of papers together with specific references to relevant pages. The title refers generally to vibration in turbomachinery, but the report is restricted to references to vibration arising from aerodynamic effects.

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CALENDAR

FEBRUARY 1984

22-24 IAVD Congress on Vehicle Component Design [IAVD] Geneva, Switzerland *(Dr. M.A. Dorgham, International Association for Vehicle Design, The Open University, Walton Hall, Milton Keynes MK7 6AA - (0908) 653945.*

27-Mar 2 International Congress and Exposition [SAE] Detroit, MI *(SAE Hqs.)*

MARCH 1984

13-15 12th Symposium on Explosives and Pyrotechnics [Applied Physics Lab. of Franklin Research Center] San Diego, CA *(E&P Affairs, Franklin Research Center, Philadelphia, PA 19103 - (215) 448-1236)*

20-23 Balancing of Rotating Machinery Symposium [Vibration Institute] Philadelphia, Pennsylvania *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

APRIL 1984

9-12 Design Engineering Conference and Show [ASME] Chicago, IL *(ASME Hqs.)*

9-13 2nd International Conference on Recent Advances in Structural Dynamics [Institute of Sound and Vibration Research] Southampton, England *(Dr. Maurice Petyt, Institute of Sound and Vibration Research, The University of Southampton, S09 5NH, England - (0703) 559122, Ext. 2297)*

30-May 3 Institute of Environmental Sciences' 30th Annual Technical Meeting [IES] Orlando, FL *(IES, 940 E. Northwest Hwy., Mt. Prospect, IL 60056 - (312) 255-1561)*

MAY 1984

1-3 Mechanical Failures Prevention Group 39th Symposium [National Bureau of Standards, Washington, D.C.] Gaithersburg, MD *(Dr. J.G. Early, Metallurgy Division, Room A153, Bldg. 223, National Bureau of Standards, Washington, D.C. 20234)*

7-10 30th International Instrumentation Symposium [Instrument Society of America] Denver, CO *(Robert Jarvis, Grumman Aerospace Corp., Mail Stop T01-05, Bethpage, NY 11714)*

7-11 Acoustical Society of America, Spring Meeting [ASA] Norfolk, VA *(ASA Hqs.)*

10-11 12th Southeastern Conference on Theoretical and Applied Mechanics [Auburn University] Callaway Gardens, Pine Mountain, GA *(J. Fred O'Brien, Director, Engineering Extension Service, Auburn University, AL 36849 - (205) 826-4370)*

JUNE 1984

26-28 Machinery Vibration Monitoring and Analysis Meeting [Vibration Institute] New Orleans, LA *(Dr. Ronald L. Eshleman, Director, The Vibration Institute, 101 W. 55th St., Suite 206, Clarendon Hills, IL 60514 - (312) 654-2254)*

JULY 1984

21-28 8th World Conference on Earthquake Engineering [Earthquake Engineering Research Institute] San Francisco, CA *(EERI-8WCEE, 2620 Telegraph Avenue, Berkeley, CA 94704)*

AUGUST 1984

6-9 West Coast International Meeting [SAE] San Diego, CA *(SAE Hqs.)*

19-25 XVIth International Congress of Theoretical and Applied Mechanics [International Union of Theoretical and Applied Mechanics] Lyngby, Denmark *(Prof. Frithiof Niordson, President, or Dr. Niels Olhoff, Executive Secretary, ICTAM, Technical University of Denmark, Bldg. 404, DK-2800 Lyngby, Denmark)*

SEPTEMBER 1984

9-11 Petroleum Workshop and Conference [ASME] San Antonio, TX *(ASME Hqs.)*

11-13 Third International Conference on Vibrations in Rotating Machinery [Institution of Mechanical Engineers] University of York, UK *(IMechE Hqs.)*

30-Oct 4 Power Generation Conference [ASME] Toronto, Ontario, Canada *(ASME Hqs.)*

OCTOBER 1984

8-12 Acoustical Society of America, Fall Meeting [ASA] Minneapolis, MN *(ASA Hqs.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics
1290 Sixth Ave.
New York, NY 10019

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

ICF: International Congress on Fracture
Tohoku University
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IMechE: Institution of Mechanical Engineers
1 Birdcage Walk, Westminster,
London SW1, UK

IFToMM: International Federation for Theory of Machines and Mechanisms
U.S. Council for TMM
c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
Owles Hall, Buntingford, Hertz.
SG9 9PL, England

SESA: Society for Experimental Stress Analysis
14 Fairfield Drive
Brookfield Center, CT 06805

SNAME: Society of Naval Architects and Marine Engineers
74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 5804
Washington, D.C. 20375

PUBLICATION POLICY

Unsolicited articles are accepted for publication in the Shock and Vibration Digest. Feature articles should be tutorials and/or reviews of areas of interest to shock and vibration engineers. Literature review articles should provide a subjective critique/summary of papers, patents, proceedings, and reports of a pertinent topic in the shock and vibration field. A literature review should stress important recent technology. Only pertinent literature should be cited. Illustrations are encouraged. Detailed mathematical derivations are discouraged; rather, simple formulas representing results should be used. When complex formulas cannot be avoided, a functional form should be used so that readers will understand the interaction between parameters and variables.

Manuscripts must be typed (double-spaced) and figures attached. It is strongly recommended that line figures be rendered in ink or heavy pencil and neatly labeled. Photographs must be unscreened glossy black and white prints. The format for references shown in DIGEST articles is to be followed.

Manuscripts must begin with a brief abstract, or summary. Only material referred to in the text should be included in the list of References at the end of the article. References should be cited in text by consecutive numbers in brackets, as in the example below.

> Unfortunately, such information is often unreliable, particularly statistical data pertinent to a reliability assessment, as has been previously noted [1].
>
> Critical and certain related excitations were first applied to the problem of assessing system reliability almost a decade ago [2]. Since then, the variations that have been developed and the practical applications that have been explored [3-7] indicate that . . .

The format and style for the list of References at the end of the article are as follows:

- each citation number as it appears in text (not in alphabetical order)
- last name of author/editor followed by initials or first name
- titles of articles within quotations, titles of books underlined
- abbreviated title of journal in which article was published (see Periodicals Scanned list in January, June, and December issues)
- volume, number or issue, and pages for journals; publisher for books
- year of publication in parentheses

A sample reference list is given below.

1. Platzer, M.F., "Transonic Blade Flutter - A Survey," Shock Vib. Dig., 7 (7), pp 97-106 (July 1975).

2. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Addision-Wesley (1955).

3. Jones, W.P., (Ed.), "Manual on Aeroelasticity," Part II, Aerodynamic Aspects, Advisory Group Aeronaut. Res. Devel. (1962).

4. Lin, C.C., Reissner, E., and Tsien, H., "On Two-Dimensional Nonsteady Motion of a Slender Body in a Compressible Fluid," J. Math. Phys., 27 (3), pp 220-231 (1948).

5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).

6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).

7. Lane, F., "Supersonic Flow Past an Oscillating Cascade with Supersonic Leading Edge Locus," J. Aeronaut. Sci., 24 (1), pp 65-66 (1957).

Articles for the DIGEST will be reviewed for technical content and edited for style and format. Before an article is submitted, the topic area should be cleared with the editors of the DIGEST. Literature review topics are assigned on a first come basis. Topics should be narrow and well-defined. Articles should be 1500 to 2500 words in length. For additional information on topics and editorial policies, please contact:

Milda Z. Tamulionis
Research Editor
Vibration Institute
101 W. 55th Street, Suite 206
Clarendon Hills, Illinois 60514

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THE SHOCK AND VIBRATION DIGEST

Volume 15, No. 11 November 1983

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CALENDAR

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5. Landahl, M., Unsteady Transonic Flow, Pergamon Press (1961).

6. Miles, J.W., "The Compressible Flow Past an Oscillating Airfoil in a Wind Tunnel," J. Aeronaut. Sci., 23 (7), pp 671-678 (1956).

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